Sci

SCIENCE

19 September 1958

Volume 128, Number 332

Editorial Oh Brave New Moon 629

Articles Use and Renewal of Natural Resources: *T. B. Nolan* 631

Science and technology can create new materials faster than consumers can exhaust present resources.

Mice, Men, and Fallout: *M. P. Finkel* 637

The potential danger of strontium-90 is appraised on the basis of data from animal experiments.

George Sarton, Historian of Science and New Humanist: *C. D. Hellman* 641

News of Science Consultant and Clearing House Service on Academically Talented; other events ... 645

Book Reviews W. Heisenberg's *Physics and Philosophy*, reviewed by *R. Rudner*; other reviews 649

Reports Nature of Meromyosins: *K. Laki* 653

Soluble Deoxyribosidic Compounds in Relation to Duplication of Deoxyribonucleic Acid: *T. S. Foster* and *H. Stern* 653

Effects of Amygdaloid Lesions upon Septal Hyperemotionality in the Rat: *F. A. King* and *P. M. Meyer* 655

Radiation-Protective Effects of Yeast Extract and Yeast Ribonucleic Acid: *K. D. Detre* and *S. C. Finch* 656

Audiogenic Abnormality Spectra, Twenty-four Hour Periodicity, and Lighting: *F. Halberg* et al. 657

Agar Substrates for Study of Microepidemiology and Physiology in Cells in vitro: *J. H. Wallace* and *J. H. Hanks* 658

Loss of Precipitating Activity of Antibody without Destruction of Binding Sites: *A. Nisonoff* and *D. Pressman* 659

Fluorescence Activation Spectra of a Diphosphopyridine Nucleotide Dependent Dehydrogenase: *A. D. Winer* and *G. W. Schwert* 660

Root Curvatures Induced by Culture Filtrates of *Aspergillus niger*: *R. W. Curtis* ... 661

Enzymatic Action of Rabbit Serum on Cortisone Acetate and Hydrocortisone Acetate: *R. B. Shouger* and *M. M. Sigel* 662

Pericentral Cortical Projections to Motor and Sensory Nuclei: *H. Kuypers* 662

Association Affairs AAAS Washington Meetings, 1854–1958 664

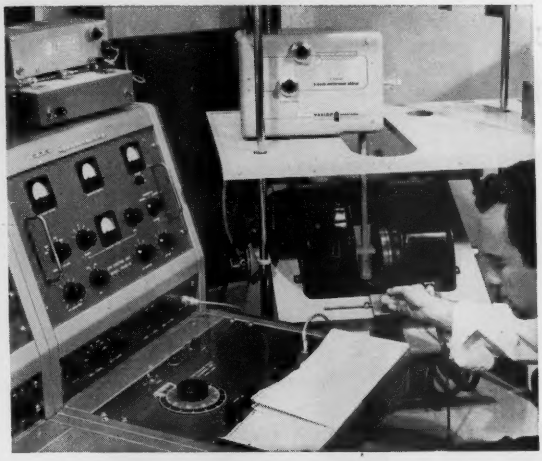
Departments Meetings; Letters; Equipment 670

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

HOW TO "SEE" AND "FOLLOW" UNPAIRED ELECTRONS

16
E-P-R
AT WORK

through EPR spectroscopy, they pinpoint conditions on a molecular scale
(Electron Paramagnetic Resonance)



EPR spectroscopy provides the scientist with a singularly exclusive "sense." It searches the specimen and sees unpaired electrons and their environmental interactions. These may be observed in many forms: free radicals – biradicals – triplet electronic states – transition element ions – semi-conductor impurities – radiation damage sites or color centers.

Interpretation of the EPR spectrum through the location and intensity of resonant peaks can often reveal quantity and identity of the unpaired electrons as well as information about the surrounding molecular structure. To assist the study of chemical kinetics, EPR spectra can be made under varying temperature and chemical environment.

In addition to manufacturing EPR spectrometers and accessories, Varian Associates maintains a staff of scientists experienced at EPR techniques and able to advise on diverse applications.

Number 16 of a series **IRRADIATION STUDIES AT VERY LOW TEMPERATURES**

INTERPRETATION: The use of cryogenics, as a means of stabilizing free radicals produced by high energy ionizing media, has been well established. The simplest cryogen that has been used most frequently is liquid N_2 at 77°K. Liquid N_2 has proved very satisfactory for most organic free radicals such as methyl, ethyl, etc., but very often there are systems which require much lower temperatures in order to stabilize the reactive species. Figures 1 and 2 illustrate such a system. Figure 1 is the spectrum obtained from a sample of ice irradiated at 77°K. The sample of distilled H_2O was placed inside a microwave cavity which was then placed inside a glass Dewar filled with liquid N_2, and this entire assembly was placed in a second glass Dewar filled with liquid N_2. The ionizing source was a 21 m.e.v. Varian Linear Accelerator delivering a peak current of 0.100 amperes. The electron beam was pulsed at 2 pulses per second for 20 seconds. The strong doublet observed could conceivably be due to the OH radical. Figure 2 is another sample of ice, contained in the same manner previously described except that the inner Dewar is filled with liquid He at 4°K. Irradiation was carried out in the same manner except that a smaller dose was administered. It will be noticed that besides the strong doublet at $g = 2.0$ two additional lines are obtained with a separation of ~ 526 gauss. These lines are assigned to the H atom resonance. Thus it can be seen that the lower temperature was necessary to stabilize H atoms in ice.

FIGURE 1 Irradiated Ice 77° K

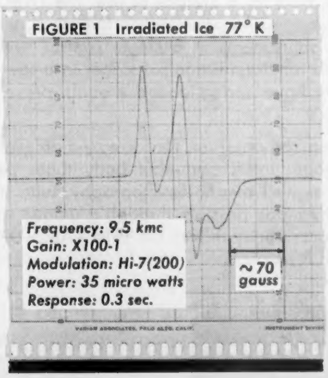
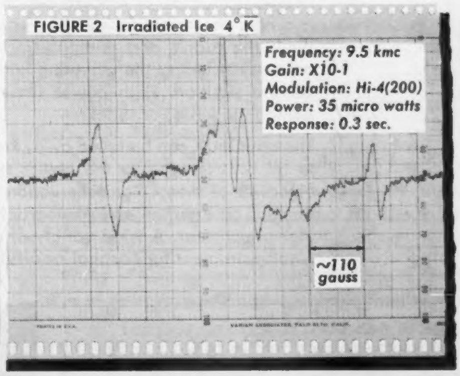
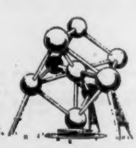


FIGURE 2 Irradiated Ice 4° K



Selected by the U. S. Government for the Brussels World Fair, Varian 60 mc NMR Spectrometer with EPR accessories is available for limited studies while on exhibit.



Write today for additional examples and information on Varian's EPR and NMR Spectrometers and services

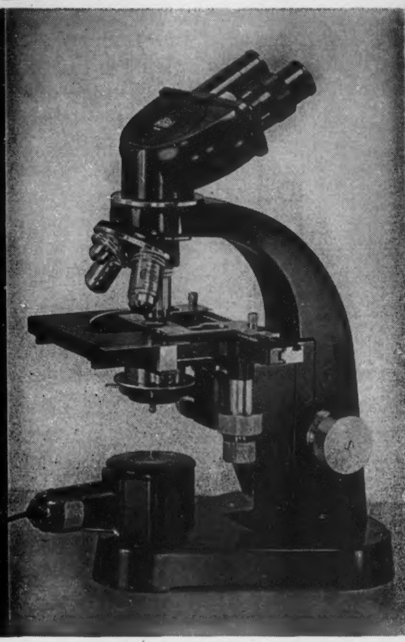
VARIAN associates
INSTRUMENT DIVISION
PALO ALTO 18, CALIFORNIA

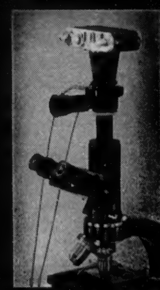
SCIENCE is published weekly by the AAAS, 1515 Massachusetts Ave., NW, Washington 5, D.C. Entered at the Lancaster, Pa., Post Office as second class matter under the act of 3 March 1879. Annual subscriptions: $8.50; foreign postage, $1.50; Canadian postage, 75¢.

A NEW CONCEPT IN MICROSCOPE PERFORMANCE

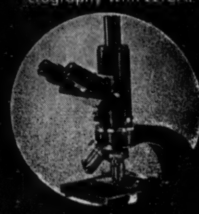
Leitz LABOLUX

LABOLUX S 47/92-15 inclined binocular microscope, with built-in mechanical stage #47, Abbe condenser; quadruple nosepiece with achromats 3.5x, 10x, 45x and 100x oil immersion, the last two having spring-loaded mounts; paired 6x and 10x binocular eyepieces; with carrying case $696.50





LABOLUX for photomicrography with LEICA.



Combined binocular-monocular tube.

The Leitz LABOLUX medical and laboratory microscope is a scientifically engineered instrument of modern design, built for a lifetime of use. The LABOLUX is a new concept in fatigue-free operation and precision performance. It combines the coarse and fine focusing adjustments in a single control; with all controls, including the actuating knob for the mechanical stage, in a low convenient position. High power lenses have spring-loaded mounts preventing damage to lenses or slides.

The LABOLUX can be faced away from the observer, for increased accessibility to all controls and to the object stage. Interchangeable body tubes permit binocular or monocular observation as well as photomicrography, with simultaneous observation and photography made possible through a unique trinocular attachment. A wide variety of accessories makes the Leitz LABOLUX the ideal instrument for hospital or office laboratory.

E. LEITZ, INC., DEPT. SC-9
468 Fourth Ave., New York 16, N.Y.

Please send me the Leitz LABOLUX brochure

Name____________________

Street____________________

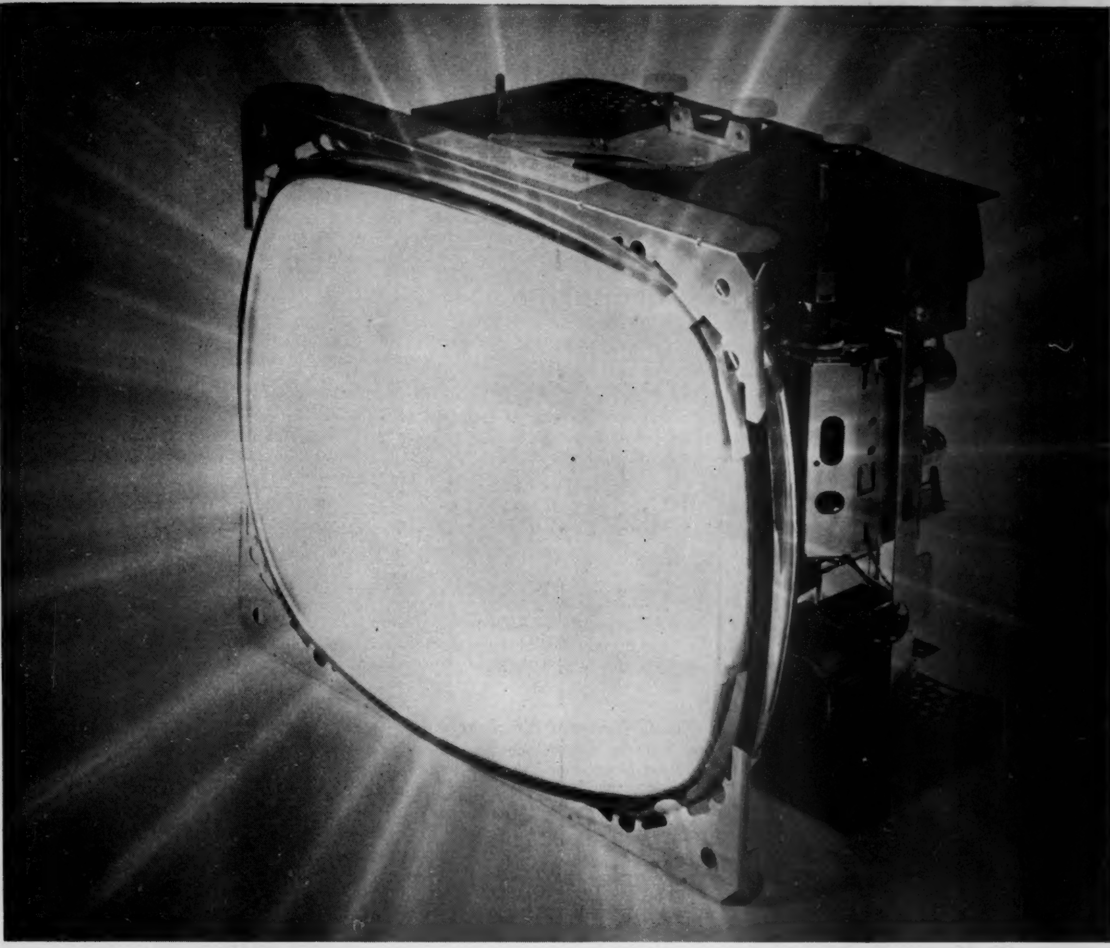
City__________ Zone_____ State_____

Leitz

FIRST IN PRECISION OPTICS

20987

E. LEITZ, INC., 468 FOURTH AVENUE, NEW YORK 16, N.Y.
Distributors of the world-famous products of
Ernst Leitz G.m.b.H. Wetzlar Germany—Ernst Leitz Canada Ltd.
LEICA CAMERAS · LENSES · MICROSCOPES · BINOCULARS



19 September 1958, Volume 128, Number 3325

SCIENCE

SCIENCE, which is now combined with THE SCIENTIFIC MONTHLY, is published each Friday by the American Association for the Advancement of Science at Business Press, Lancaster, Pa. The joint journal is published in the SCIENCE format. Entered at the Lancaster, Pa., Post Office as second class matter under the Act of 3 March 1879. SCIENCE is indexed in the *Reader's Guide to Periodical Literature*.

Editorial and personnel-placement correspondence should be addressed to SCIENCE, 1515 Massachusetts Ave., NW, Washington 5, D.C. Manuscripts should be typed with double spacing and submitted in duplicate. The AAAS assumes no responsibility for the safety of manuscripts or for the opinions expressed by contributors. For detailed suggestions on the preparation of manuscripts, book reviews, and illustrations, see *Science* 125, 16 (4 Jan. 1957).

Display-advertising correspondence should be addressed to SCIENCE, Room 740, 11 West 42 St., New York 36, N.Y.

Change of address notification should be sent to 1515 Massachusetts Ave., NW, Washington 5, D.C. 4 weeks in advance. If possible, furnish an address stencil label from a recent issue. Be sure to give both old and new addresses, including zone numbers, if any.

Annual subscriptions: $8.50; foreign postage, $1.50; Canadian postage, 75¢. Single copies, 35¢. Cable address: Advancesci, Washington.

Oh Brave New Moon

When someone in industry or government wants to let the world know about an invention or an improved process, he arranges a press conference complete with food or food and drink, a speaker or two, a movie projector, and, as the *pièce de résistance,* a gadget to be unveiled. If the project is "classified," the unveiling is incomplete—the works of the gadget are not fully exposed—and the dramatic effect is not as great as the sponsors would wish. So also in such conferences the answers to questions are often reminiscent of the reluctant testimony sometimes offered to Congressional committees. The thrust and parry may go something like this: "Would you say that the XK-93 has ten times as much potential velocity as the XK-79?" *Answer* (blandly, in a self-righteous tone): "All that security regulations permit me to disclose is that the XK-93 has substantially greater velocity than its immediate predecessor and that we feel it is an advanced design." One almost expects the spokesman to plead the Fifth Amendment.

Conferences dealing with nonsecret matters follow a different course: questions and answers range over a wide area, and speculative forecasts can be discussed. We recently attended a breakfast conference of this kind to hear some Westinghouse Electric Corporation scientists talk about the requirements for a manned base on the moon. Westinghouse scientists think a manned base would have to be essentially self-sustaining to be practicable. The costs of space transport being what they are, they envision a very lightweight electrical generating system as the heart of a self-supporting base. Given such a system the lunar pioneers could generate heat to set oxygen free from the oxides presumably present and could release hydrogen from hydrides. The hydrogen and oxygen could be combined to produce water. In a similar way the stage could be set for photosynthesis by freeing carbon dioxide from carbonates. In addition, a lunar technology could be developed to produce structural materials, rocket fuels, and so on.

Potential power systems on the moon are obviously fewer than those that are economically usable on earth. No one, for example, wants to buck the mass ratio (ratio between take-off mass and burn-out mass) by sending conventional fuels into space. Even lightweight and unshielded nuclear reactors would weigh several kilograms per kilowatt of capacity. The high intensity of solar radiation on the moon points to a generating system that would exploit this advantage by use of solar furnaces, solar batteries, devices to take advantage of geothermal (lunathermal?) gradients, or—and this is at present scarcely more than a gleam in the corporate eye—a photoelectric generating system consisting of a plastic sheet coated with a light-sensitive electron emitter and a wire grid.

Such a system as the last is especially suitable for the moon because of its light weight and the fact that it will function only in a vacuum. The gadget that Westinghouse unveiled was a small working model of this system. Questioning of the company spokesman made it apparent that a good many improvements will have to be made before a photoelectric generator will be practicable. The model demonstrated had an efficiency of about 0.1 percent; to be attractive for lunar operation it should have an efficiency of about 25 percent. If this efficiency can be attained—and the engineers seemed confident that it can—then the system will be able to produce about 1200 kilowatts per acre at a weight of only 1.7 kilograms per kilowatt.

Before this kind of system can be tried out on the moon a number of obstacles—too familiar to be listed here—will have to be overcome. And we continue to be haunted by the possibility that the moon's surface may be, as John R. Platt recently suggested [*Science* **127**, 1502 (27 June 1958)], so chemically unstable that exothermic reactions would be easily set off and that "the first man who plants a rubber boot on a lunar surface may be in for an unpleasant surprise."—G.DuS.

19 September 1958, Volume 128, Number 3325 SCIENCE

Use and Renewal of Natural Resources

Science and technology can create new materials faster than consumers can exhaust present resources.

Thomas B. Nolan

The 50th anniversary of the Conference of Governors, called by President Theodore Roosevelt in 1908 to attack the "weightiest problem . . . before the Nation" (*1*, p. 3)—the conservation of its natural resources—seems an appropriate time to call attention to the often overlooked role of scientists and engineers in that conference. Of even greater interest, however, has been the influence of these two professions in very materially changing the nature of the movement during the 50 years that have elapsed since 1908.

I propose to mention only briefly the early interest of scientists and engineers in conservation and to devote most of my space to a discussion of the thesis that there have been major modifications in the nature and objectives of the conservation movement since 1908, and that these changes, to a marked degree, result from the much more reassuring picture of our natural resource situation brought about by the research accomplishments of physical and biological scientists and the technological advances of the engineers.

To judge from the records of the Governors Conference, many of the men who assisted Gifford Pinchot and Theodore Roosevelt in its organization were the younger associates or successors of a small group of scientists, engineers, and administrators who were active in Washington during the last quarter of the 19th century, and who had participated in the explorations that led to the opening of the West. Later they had become involved in the problems that arose during its development. Through their association with both the governmental and scientific agencies in Washington and the national professional organizations, they exerted a considerable influence on both the intellectual and political thinking of the country.

Several of the early geologists and engineers of the Geological Survey were members of this group. One of them, John Wesley Powell, the second director of the Survey, was especially influential.

One of the photographs which adorns the Survey director's study is of the Survey "lunch mess" of the '90's. This was one of several similar gatherings that appear to have been a feature of the scientific bureaus of Washington in the latter part of the last century. It includes, besides Powell, W J McGee and F. H. Newell, two men who appear to have played major roles in assisting Gifford Pinchot to organize the 1908 meeting. It also includes at least four others who were "general guests" of the White House Conference. One can imagine that the discussions at such luncheon gatherings as this were instrumental in formulating the plans and developing the policies of the newly emerging conservation group. The proposals of these men must have been especially effective since they were based on the knowledge of individuals who had appraised the resources of newly explored regions and had endeavored to control their development.

In developing my thesis that science and technology have changed the nature and objectives of the conservation movement, I propose first to review the original concept of conservation, next to examine the present situation in several of the resource fields in comparison with that pictured by the speakers at the Governors Conference in 1908, and finally to suggest some conclusions that seem to me to follow from this review (*2*).

Concept of Exhaustion

I believe the evidence is quite conclusive that the impelling reason for the widespread acceptance of the conservation movement in the early part of the century, as well as the specific justification for the Governors Conference, was fear—fear of exhaustion of the natural resources upon which the national economy was based and concern that survival of the nation might be dependent upon ability to achieve restrictions in use that would postpone or alleviate the effects of such exhaustion.

The communication of the Inland Waterways Commission to Theodore Roosevelt that led to the conference called attention to an "unprecedented consumption of natural resources," and "exhaustion of these resources" (*3*). President Roosevelt clearly accepted this view, and in his letters to the governors

Dr. Nolan is director of the U.S. Geological Survey. This article is one of a series of lectures given in the Winter 1958 Resources for the Future Forum, "Natural Resources Conservation in the United States—History and Prospects." It was presented 23 Jan. 1958 at the Cosmos Club, Washington, D.C. It is published with the permission of Resources for the Future, Inc. and the Johns Hopkins Press, which will publish the entire series in book form.

calling the conference declared, ". . . there is no other question now before the Nation of equal gravity with the question of the conservation of our natural resources. . . .

"It is evident the abundant natural resources on which the welfare of this Nation rests are becoming depleted, and, in not a few cases, are already exhausted" (*4*).

This theme was even more vigorously presented in his opening address to the conference. He said, for example:

"I have asked you to come together now because the enormous consumption of these resources, and the threat of imminent exhaustion of some of them, due to reckless and wasteful use, once more calls for common effort, common action.

"We want to take action that will prevent the advent of a woodless age, and defer as long as possible the advent of an ironless age" (*1*, p. 6).

This keynote of fear for the future because of exhaustion of natural resources was a recurrent one throughout the conference and was emphasized by some of the more eminent and influential participants. Andrew Carnegie, for example, predicted that our Lake Superior iron ores "will be exhausted before 1940" (*5*, p.17), and J. J. Hill, of railroad fame, expected that our supply of some varieties of timber would be practically exhausted in 10 or 12 years. He was, moreover, concerned that the yield per acre for various agricultural products had decreased and attributed this diminishing return to soil destruction. His statement that "we are approaching the point where all our wheat product will be needed for our own uses, and we shall cease to be an exporter of grain" might well be regarded as wishful thinking today—rather than as a matter of deep concern (*6*, p. 72).

Similar predictions were made concerning essentially all of the natural resources. One speaker made one of the first of many similar later reports that "the supply of natural oil and gas is limited and uncertain and the amount available is required for special industries" (*7*, p. 293). He also anticipated exhaustion of domestic anthracite coal supplies in 60 to 70 years. Other speakers predicted exhaustion of phosphate supplies for fertilizer, one of them expecting it to be so near in the future that he reported that "there is not fertilizer enough to be gotten in the market to supply all the American farmers" (*8*).

Equally bleak forecasts for future water-power supplies were made, and Hill's concern over the future supplies of agricultural and forest products was endorsed. An electrical engineer, for example, reported that "the supply of water power is limited . . . and great care, therefore, must be exercised to insure [its] preservation" (*7*, p. 295).

Few of the speakers probably unreservedly accepted one governor's prediction that "the American People are on the verge of a timber famine" (*9*), but the concept of exhaustion was widely accepted and appears to have dominated the conference's deliberations.

Other views were, of course, expressed, and some of them are not at all dissimilar to much of present-day thinking. Two speakers particularly anticipated the current emphasis on wise use. Edmund James emphasized the need for "so organizing and utilizing our natural resources as to produce in the large and in the long run the greatest return in the form of material wealth to the Nation." He also observed that "we shall add far more to our natural resources by developing our ability to increase them than we can ever do by mere processes of saving" (*10*). Andrew Carnegie also pled for more knowledge: "but especially I urge research into and mastery over Nature . . . our greatest need today [is] the need for better and more practical knowledge" (*5*, p. 24).

On the whole, though, the emphasis on exhaustion prevailed, and the "Declaration" of the conference, adopted shortly before the sessions were adjourned, reiterated that theme (*11*).

These predictions that supplies of iron ore, fuel, timber, water power, and even grain would become inadequate or be exhausted in a relatively few years after 1908 appear surprising to us today, when we consider the proposals that have been made in recent years to provide subsidies of various kinds to domestic producers of these commodities because of existing oversupplies. The threatened exhaustion not only has not occurred but, for some commodities, we are seriously proposing research programs to develop new uses, in order that existing capacity for production can be utilized.

Present-Day Objectives

I have called attention to these predictions of 50 years ago not to ridicule the individuals who made them but to make clear the basic assumptions upon which the initial concept of the conservation movement rested, and to bring out the extent of the change from it to the present-day one. We now characterize conservation objectives, insofar as natural resources are concerned, as those promoting wise use of the resource: practices that will provide a sustained yield so far as the renewable resources are concerned, or those that will achieve orderly development without waste, in the case of nonrenewable ones.

Increasingly too, conservation has meant the utilization of resources in such a way as to preserve the social and esthetic values of the natural environment for succeeding generations. Leopold (*12*) has recently implied that this may ultimately become the objective of the movement, since increasingly the adequacy of supply of such resources as water and minerals has become a matter of economics.

This represents a major change in the meaning of conservation—a change from the negative objective of restriction of use [Carnegie (*5*, p. 24) phrased it as "economy, that the next generation and the next may be saved from want"] to the positive one of better utilization of our resources and our environment in order to make possible better and fuller lives for all the people.

I believe that this change could only have come about as a result of a popular acceptance of the concept that the resource base for the national economy was not in immediate danger of exhaustion. This reassurance came about in part through the development of additional supplies, in part through supplementing existing resources by substitute materials, and in part by better utilization practices. It has been easy for most of us to accept, for even the most casual observer is aware of the increased standard of living, with the attendant increase in the amount and variety of resources on which it is based, on the one hand, and the troublesome recurrent surpluses of supply of so many commodities, on the other.

To me it is also clear that this expansion of the resource base is the product of science and technology. It is an interesting speculation that the concern over exhaustion of natural resources, apparent at the Governors Conference, stimulated research by physical and biological scientists and engineers in this field. Whatever the cause, research has been active and has been productive of results.

A brief review of the changes in our resource situation brought about by research in each of the major fields will, I hope, document this belief.

Nonrenewable Resources

The field of nonrenewable resources—the mineral raw materials and fuels—is one with which I am most familiar and which I will, therefore, discuss first and in somewhat more detail than the others. It is especially noteworthy, too, that even for these natural resources, which, as everyone knows, cannot be replaced when once consumed, we now think of the means by which needs for these commodities can be met rather than express concern over their imminent exhaustion.

How has this change in opinion come about? In general, it has been a gradual process that has been in part the result of new or potential production from sources that were unknown or not regarded as capable of exploitation in 1907 and in part, the result of the development and utilization of substances that supplemented or replaced the common materials of the past.

I had the privilege of reviewing these developments at the initial meeting of Resources for the Future a little over four years ago (*13*); it will be helpful, and instructive, I believe, to examine that review and bring it up to date. It was proposed at that time that three major fields of research had been, and would continue to be, productive in expanding our resource base for the useful expendable materials.

The first of these major fields of research is that directed toward a better understanding of the origin of the kinds of deposits currently being exploited and toward related studies on new and improved tools and techniques by which additional, like deposits could be found, even though they might not be exposed at the earth's surface.

Petroleum

The petroleum industry is probably the best example of the effectiveness of this approach. It has provided the country with proven reserves of petroleum that are today sevenfold larger than those of only 35 years ago. I believe that this can, to a large degree, be attributed to industry-supported studies on the origin of oil and the factors that control its migration and accumulation, as well as to a most elaborate and effective development of geologic, geochemical, and geophysical techniques and instruments that have improved our ability to locate petroleum accumulations economically and efficiently.

It is true that we still must face the eventual exhaustion of our oil fields, and Hubbert (*14*) has recently prepared an interesting and instructive discussion which outlines the future decline in the rate of discovery and production. But his predictions are a far cry from those of twenty or more years ago, which appraised our total future supply as significantly less than the production that has been made since then, let alone the even larger proven reserves that are presently known.

The older reserve estimates have been completely invalidated by the great strides that have been made through the use of geology, geophysics, and engineering in finding and extracting petroleum from the ground. The various types of stratigraphic traps in Texas and the mid-Continent Region, the reservoirs adjacent to the salt domes of the Gulf Coastal Plain and the Continental Shelf and those bordering the ancient reefs of Texas, and the Williston Basin of North Dakota and western Canada have added to our primary reserves and are the result of the increased capacity of the petroleum geologist to predict, and find, concentrations of oil and gas in environments that were poorly understood not too many years ago. And the increased yield from known fields due to the work of the petroleum engineer on secondary recovery methods and on induced fracturing in the reservoir rocks has further enlarged our known reserves.

Moreover, we can view the possibility of exhaustion of even these reserves with some equanimity in the light of our research-derived capacity to produce synthetic liquid fuels from the tremendously large reserves of oil shales, tar sands, and, in the still more distant future, low-grade coals.

Metallic and Nonmetallic Minerals

Progress in increasing our resource base for the metallic and nonmetallic mineral resources has lagged behind that for petroleum, largely because demand for these commodities did not increase with the same rapidity as that provided for petroleum products by the internal-combustion engine. But there is considerable evidence that support of research on the origin of these deposits and into the means of exploring for them is increasing, both in industry and in government, and is beginning to bear fruit.

We are at the moment, unfortunately, more concerned with selling and utilizing the products of our copper, our lead-zinc, and our tungsten mines than in finding additional sources to bring into production, but recent years have seen the discovery of new and significant deposits of metalliferous minerals, which greatly expand our capacity for future production. The new lead-zinc deposits of New Brunswick, in Canada, and of Tennessee, the new copper deposits in Arizona, the iron and lead deposits of southeast Missouri, and the immense rare-earth occurrence in the Mountain Pass district in California are examples of discoveries that, to a large extent, have been the result of research-guided exploration and of new techniques, such as the use of airborne geophysical instruments and geochemical prospecting methods. There are sound theoretical grounds for believing that many additional deposits remain to be found through sharpened and improved concepts of origin and through the use of new and more elaborate exploration tools. Engel's recent study (*15*) of variations in the ratio of the isotopes of oxygen in some minerals associated with ore deposits, and the possibility that such variations may reflect temperature gradients existing at the time of ore deposition, is an exciting example of the techniques. Barton (*16*) similarly has opened up the possibility of predicting the environment in which ore minerals may be deposited, through his work on the equilibrium relations of these minerals.

The additions to our resource base now being made through better knowledge of presently mineable ore bodies and improved exploration methods and techniques will be supplemented in the future to an increasing extent by research on subgrade and ultrasubgrade material. The study of the distribution of elements in the earth's crust in concentrations that are too small to be presently workable is already pointing the way to accumulations in which two or more elements or substances are present in trace amounts but which, in combination, may represent potential sources of very large magnitude. In addition, increased requirements or new and improved recovery methods may make much material merchantable that is presently below acceptable grade.

It appears that many elements may be distributed through the crust in such a way that there is an inverse relationship between the quantity or tonnage of material containing the particular element and the grade or concentration of the

element. The impact of more detailed knowledge of this matter on potential supply may well be tremendous.

Two examples will illustrate what may be expected with continuing "trace-element" research, especially if it be combined with economic incentive. The first pertains to our domestic resources of uranium. Initially we were essentially dependent upon the high-grade deposits of the Belgian Congo and Canada; these ores contained 20 pounds or more per ton, and the quantities of ore were not impressively large. Recognition of the need for additional supplies at the close of World War II led to one of the most extensive and thorough programs of research on occurrence and of exploration that has been carried out in recent years. Much of the research was concentrated on phases of trace occurrences of uranium and on factors causing local relative concentrations. This has been phenomenally successful; we now have well-established reserves amounting to approximately 70 million tons of material containing about 5 pounds per ton (*17*), and are using new recovery methods that have proved to be entirely satisfactory and that are employed in a dozen or so new plants. In addition, there are even larger quantities of phosphate rock containing less than ½ pound per ton from which uranium can be (and already has been) recovered as a by-product. And, finally, there are literally billions of tons of easily mined black shales, containing in the neighborhood of 1/10 pound per ton, that constitute a future reserve when, and if, still more uranium is needed. Lest this last be dismissed as a completely impractical source, I will observe that Hubbert calculated the energy value of the uranium in a ton of this average shale as equivalent to that in nearly 1000 barrels of petroleum (*14*, pp. 33–35).

A second example of a trace-element resource not yet exploited, but which I am convinced will be some day, is the Phosphoria formation, a rock unit of the Rocky Mountain Region. It includes, as separate beds, most of the high-grade phosphate rock in the western United States, and, in addition, it contains significant trace amounts of a number of metals, including uranium, vanadium, the rare earths, silver, nickel, zinc, and molybdenum, as well as appreciable quantities of fluorine, distillable hydrocarbons, and sulfur. McKelvey and his coworkers (*18*) have estimated that the formation is present over a large part of a 135,000-square-mile region. Within this area, the formation contains billions of tons of phosphate. In recent years a great deal has been learned about the distribution and amount of the trace elements in the formation; on the basis of present knowledge, it is estimated that a thickness of 50 feet or more of rock, extending over several hundreds of square miles, may contain more than half a dozen commodities with a gross value of something in the order of $5 a ton.

Finally, I am convinced that a still further extension of our resource base for mineral raw materials will come about through research into the basic physical and chemical properties of the elements and their compounds, with the objective of developing synthetic or substitute materials. Indeed, it seems entirely probable to me that in the future we may be able to invent, or produce out of abundant materials, new substances that have predictable, specific desired properties. A first step along this line is already well under way, and substances are being developed to provide particular, desirable properties. The relatively new field of powder metallurgy has provided one means of accomplishing this; one of its techniques—that yielding the so-called "cermets" and "cermet coatings"—has been especially fruitful. These substances may be considered to comprise refractory carbides, nitrides, borides, silicides, or oxides with or without a cementing metal. Some combine high chemical stability and oxidation resistance with high strength and low density (*19*).

Events of the four years that have elapsed since this earlier review of our nonrenewable resources have strengthened the conclusion that was reached then, that "it does not seem too improbable that, through one or another of the methods of improved exploration techniques, exploitation of presently unavailable supplies, or programs of substitution and improved utilization, raw materials for our civilization can be obtained for a long period in the future" (*20*).

Water Resources

I believe a similar conclusion may be reached in respect to our water resources. Water, unlike minerals and the mineral fuels, is a renewable resource. Thanks to the automatic operation of the hydrologic cycle, our supply is continuously, but not always uniformly, replenished by rainfall. Although three-quarters of the precipitation which falls is returned to the atmosphere by evapotranspiration and only one-quarter is currently available for man's use, we are in this country using only one-fifth of this smaller available amount. And of this one-fifth that we do use, approximately one-half is applied to what are regarded as nonconsumptive uses—that is, this amount is subject, within certain limits, to repeated reuse. Hence, in the broadest sense, our water resources are not only renewed by natural processes but, in theory at least, the use of about one-half of them is subject to almost unlimited expansion.

A number of the papers given at the 1908 conference expressed concern over the continued adequacy of our supply of water. Irrigation, water power, and inland waterways appear to have been considered as requiring the preservation of our water resources, and protection of a forest cover seems to have been considered the major factor in such a preservation. Curiously enough, little attention was given to industrial supplies, which now account for about half of the present water use. Nor was there recognition of the nonconsumptive character of the water-power use.

We still have problems concerning adequate supplies of water, although the use pattern is significantly different from that of 50 years ago. And as the drought in the Southwest of a year ago made dramatically clear, water shortages may have a devastating effect upon the economy of a community or region. Luna Leopold, however, in a recent illuminating discussion of "Water and the Conservation Movement" (*12*, p. 6) makes clear that our current problems of water surpluses or shortages, serious as they may be locally, are basically not problems of conservation so much as of economics. Except for the problems that arise through our desire to preserve portions of the original environment of the nation, he considers that "all our other water problems are problems of shortage due to geographic and time variations, which, important as they are, can be reduced to problems of economics. Economic problems gradually become solved by the play of forces inherent in the market place. Water will be used in those places and for those purposes which can best afford to bear the cost under prevailing conditions."

Leopold's conclusion is in effect another way of stating that we are now able to solve our water problems, not by curtailment of use or other restrictive measures based on possible exhaustion, but by utilizing our knowledge of the hydrologic cycle, gained through extensive research over past years, and our capacity to transport or regulate water on a scale vastly greater than in the past as a result

of technologic advances. Our concern is not with running out of water that is needed to accomplish certain desirable or necessary things but with whether the expenditure of labor and materials is justified by the results to be obtained. Use, rather than restrictions on use, controls our thinking.

I believe it is also true, as was suggested in the discussion of mineral raw materials, that we have by no means exhausted our capacity to increase the amount of water available for use. From the knowledge gained through research into particular segments of the hydrologic cycle, there are good grounds for believing that the usable fraction of the water that reaches the earth as rainfall can be somewhat enlarged over the one-fifth now considered to be the maximum. Current studies on the principles of evaporation, for example, are greatly increasing our knowledge of the relative importance of the factors that affect the process (*21*); with this increased knowledge comes the ability to influence one or more of them in a way to decrease current evaporation losses, such as the experimental work now being done on the use of a monomolecular film of a nonpermeable solid on the surface of ponds and reservoirs (*22*). Similar studies of the transpiration process seem to hold promise. Other research in progress on recharge to underground aquifers and on the nature of the salt-water–fresh-water interface in coastal areas, as well as continuing study of the mechanics of groundwater flow, gives promise of materially increasing our ability to expand wisely the use of existing supplies of underground water.

And perhaps still further in the future will be the possibility of economic justification for conversion of saline water to fresh water. It seems certain that further work will greatly increase the number of areas in which one or another of the several processes now under study may be economically justified. If, for example, oil-field brines and other saline ground waters could be economically treated, many places in the arid or semiarid Southwest might have their current water problems greatly alleviated for domestic and industrial uses.

Soils and Forest Resources

I am not especially familiar with the changes that have occurred in the two other major fields that were considered by the Governors Conference—soils, and the foods produced from the soil, and forest resources. But there can be little doubt that the 1908 conferees were seriously concerned about the possibility of an inadequate future supply of food and forest products (exhaustion in the case of renewable resources being an unlikely end result) and of accelerated erosion of soil, as a result of the exploitation of forest and range that was being so vigorously carried on as our country was being developed.

Perhaps the most graphic means of bringing out the magnitude of the change in our national situation, so far as food and forest products are concerned, is to contrast the statements of J. J. Hill (*6*, pp. 65, 72) that, both for timber and grain, the United States would face within the century either exhaustion or dependence upon imports with the introductory statement of the recent report of the Commission on Increased Industrial Use of Agricultural Products (*23*): "American farmers have succeeded so well in the necessary effort to increase their efficiency that they now consistently outrun the capacity of the economy to consume what they produce. . . . Though population is growing and living standards are rising, the productive capacity of our agriculture promises for many years to keep increasingly ahead of both."

The report of this committee is really a most impressive testimonial of the effectiveness of the research programs in agriculture and forestry during the last 50 years; it is encouraging to consider that in some respects these programs are analogous to the threefold research program now being initiated in the minerals field. The widespread acceptance of such practices as crop rotation in agriculture and of the principle of sustained yield in forestry has increased the resource base in the same way that improved exploration techniques have increased it in the mineral resource field. And the success of the studies on plant breeding, on the control of pests and blights, and on improved cultivation practices has had an effect in increasing yields comparable to that of utilization of lower and lower grade material in minerals. Finally, the noteworthy advances in utilization of food and forest products, through the research activities of the Forest Products Laboratory and the Agricultural Experiment Stations, have not only eliminated much of the waste that concerned the conferees of 50 years ago but have, especially for forest products, actually increased the resource because of a new ability to utilize the waste products for the same purposes for which the primary product is utilized.

The situation in regard to soils, in contrast to products of the soil, is basically more like that of mineral resources, since the production of soil from rock is a geologic process and can be accomplished only in units of geologic, rather than everyday, time. I have the impression that our slower progress in better utilizing and in expanding our soil resources lies partly in our failure to appreciate this, and partly in our lack of knowledge of the nature of the erosion that locally so dramatically destroys or removes some of our best soils.

I suspect also that far too little research has been done on the details of processes in soil-profile development and other aspects of soil morphology. The present practice of soil classification will probably be revised as such additional knowledge becomes available, and improved classification schemes, better founded on soil morphology, might make possible a more rational separation of soils adapted for different use. Under such an improved classification scheme some soils might best be used for agriculture, some for forestry, still others, as areas of ground-water recharge or for other water-management purposes.

Although the effectiveness of erosion-control programs has increased, this improvement has come principally, in my opinion, from empirical trials rather than from a greatly increased depth in knowledge of the erosion process. Basic understanding of principles appears to me to offer the main source of further improvement in erosion management techniques.

We cannot, of course, prevent erosion in the broad sense, any more than we can prevent, in the broad sense, aging or growth in plants or animals; we can, in a small, but to a constantly increasing, degree modify such phenomena and take advantage of our knowledge of the controlling principles in order to achieve effects more nearly in accord with our desires. Soil conservation practices, based on such knowledge, give great promise, not only in the maintenance of present soil resources but also in the reduction of the sediment load carried by streams and deposited in reservoirs. A preliminary report on Brandywine Creek, Delaware, shows evidence of the effectiveness of land management programs for control of sediment (*24*); it indicates a reduction of 38 percent in the sediment load from this small eastern drainage basin within an 8-year period as the result of adoption of a watershed treatment program, with practically no dams or other structures.

In general, we can say that watershed treatment programs will be especially effective in control of sediment movement; their effect on the disposition of water probably needs more study before we can arrive at a definite conclusion.

I am also intrigued with the long-range possibilities of research on the nutritional requirement of specific crops, including laboratory studies in hydroponics. Further work in this field may make possible a much more effective utilization of fertilizer resources as well as a more intelligent correlation of soil types with particular crops.

Conclusions

I fear that some of my conservationist friends will feel that I have been unduly optimistic in my confidence that scientific research and technologic development have to a large extent eliminated from the conservation movement concern over the adequacy of our resource base. They will, quite correctly, point to a number of commodities, and to a number of localities, in which adequacy is far from assured (areas in which ground-water supplies are being drastically, and perhaps permanently, depleted is one example).

But I am unwilling to acknowledge that such existing local, or specific, individual shortages invalidate my firm conviction that continuing research, combined with man's ingenuity, can be depended upon to resolve the problems. To me, one of the lessons to be learned from the 1908 conference is the danger of extending into a future that will be predictably in a state of disequilibrium projections that are based on static conditions. Carnegie's prediction (*5*, p. 17) that the Lake Superior iron ores would be exhausted before 1940 contrasts with a recent estimate of high-grade reserves still in the ground that is significantly larger than the amount he reported for 1907, and of reserves of potential ore nearly 100 times as great. And in the other direction, his prediction of coal production for 1937 was eight times too large.

Other examples might be cited, and, in general, it would seem that the more eminent and successful the speaker, the more his prediction was likely to be in error in the direction of imminent exhaustion. It would appear that this inability to predict accurately might be correlated with the necessary intense concern with, and profound knowledge of, existing conditions that characterize the successful man of affairs. Conversely, though, it implies an inability to comprehend man's capacity to adjust to, and devise means to seek control of, a changing physical, economic, and intellectual environment.

I suppose there will be always a tendency to accept a concept of conservation that is based on exhaustion and that proposes restriction in the use of resources, simply because it is so easy to project the present. But I cannot concur that such a concept can ever prevail, since it ignores the fact that continual change, rather than permanent stability, is characteristic not only of the earth but of its inhabitants. I believe that the prospect of impending shortages or unsuitable supplies will continue to inspire the research and technical advances that will make it possible to resolve such problems well in advance of the doom we often are prone to foresee.

We probably need to fear, not the exhaustion of physical resources, but the dangers of inadequate or belated utilization of our intellectual resources. I hope we are currently rediscovering the need to practice this kind of conservation.

Wider recognition of the part that science and technology have played in the conversion of conservation from a movement based on fear to one calling for wise use of presently used resources and the preservation of social and esthetic values may well stimulate research by the social scientists and humanists to seek comparable progress towards the newer objectives.

I have not specifically considered in this article the dilemma that appears to confront modern civilization, and which is at the root of many of the more restrictive statements of conservation: the problem posed by an assumed infinite population in a finite world. Personally, I believe it to be another example of the dangers of projecting current trends into what we can be sure will be the changed world of tomorrow. Edward Teller has recently phrased this belief more felicitously than I can, however, and his conclusion is an apt one with which to conclude (*25*):

"Of all long-range prophecies, the theory of Malthus may well be the most plausible and the most inaccurate. About 150 years ago he predicted that the population of the earth would tend to increase faster than the food supply. Since he made his dire predictions the rate of population increase has continued to reach higher and higher levels—and so has the standard of living throughout most of the world. It is true that conditions are wretched in many countries; but even where life is hard people are objecting not because they look back to a happier past but rather because they demand a better future—which they know can be realized. Human fertility is undoubtedly great, but so far human ingenuity has proved greater. I suspect that ultimately the population of the earth will be limited not by any scarcity but rather by our ability to put up with each other."

References and Notes

1. T. Roosevelt, "Opening address by the President," in *Proceedings of a Conference of Governors in the White House, Washington, D.C., 13–15 May 1908* (1909).
2. I am indebted to H. M. Bannerman, Julian Feiss, and Luna B. Leopold for helpful criticism and suggestions, and to Jane Wallace for very material assistance in the preparation of this article.
3. T. E. Burton and W J McGee, "Letter (3 Oct. 1907) to the President of the United States, Theodore Roosevelt," in *Proceedings of a Conference of Governors in the White House, Washington, D.C., 13–15 May 1908* (1909), p. viii.
4. T. Roosevelt, "Letter (Nov. 1907) to the Governors of the United States," *ibid.*, p. x.
5. A. Carnegie, "The conservation of ores and related minerals," *ibid.*
6. J. J. Hill, "The natural wealth of the land and its conservation," *ibid.*
7. H. St. C. Putnam, "Conservation of power resources," *ibid.*
8. J. Wilson, "Address by the Secretary of Agriculture," *ibid.*, p. 97.
9. E. S. Stuart, "Conservation of Pennsylvania's resources," *ibid.*, p. 327.
10. E. J. James, "Address by the President of the University of Illinois," *ibid.*, pp. 174, 178.
11. N. C. Blanchard *et al.*, "Declaration of the Governors," *ibid.*, pp. 192–194.
12. L. B. Leopold, "Water and the conservation movement," *U.S. Geol. Survey Circ. No. 402*, (1958).
13. T. B. Nolan, "The way ahead for research in nonrenewable resources," in *The Nation Looks at its Resources* (Resources for the Future, Inc., Washington, D.C., 1954), pp. 314–316.
14. M. K. Hubbert, "Nuclear Energy and the Fossil Fuels," *Shell Development Co. Publ. No. 95* (1956).
15. A. E. J. Engel and C. Patterson, *Bull. Geol. Soc. Am.* 68, 1723 (1957).
16. P. B. Barton, Jr., *Econ. Geol.* 52, 333 (1957).
17. J. Johnson, "Uranium production in the United States," address delivered to the 4th Annual Conference of the Atomic Industrial Forum, New York, 28 Oct. 1957.
18. V. E. McKelvey, R. W. Swanson, R. P. Sheldon, "The Permian phosphorite deposits of western United States," *Proc. 19th Intern. Geol. Congr.* (1953), fasc. xi, p. 56.
19. A good summary is provided in "Powder Metallurgy," *Tech. Assistance Mission No. 141* (Organisation for European Economic Co-operation, Paris, 1955).
20. T. B. Nolan, *Econ. Geol.* 50, 7 (1955).
21. *U.S. Geol. Survey Profess. Paper No. 269* (1954); *U.S. Geol. Survey Profess. Paper No. 270* (1954); G. E. Harbeck, M. Kohler, G. E. Koberg *et al.*, *U.S. Geol. Survey Profess. Paper No. 298*, 1958.
22. G. E. Harbeck, "Can Evaporation Losses Be Reduced?" address delivered at 1st Intersociety Conference on Irrigation and Drainage, San Francisco, Calif., 29 Apr. 1957; I. Langmuir and V. J. Schaefer, *J. Franklin Inst.* 235 (1943).
23. J. L. Welsh *et al.*, "Report to the Congress from the Commission on Increased Industrial Use of Agricultural Products," *Senate Document No. 45* (1957), p. xiii.
24. H. P. Guy, "The Trend of Suspended Sediment Discharge of the Brandywine Creek at Wilmington, Delaware, 1947–1955," *U.S. Geol. Survey Open File Rept.* (1957).
25. E. Teller, *Lamp* 39, 5 (1957).

Mice, Men, and Fallout

The potential danger of strontium-90 is appraised on the basis of data from animal experiments.

Miriam P. Finkel

During the past few years a great deal of effort has been devoted to discovering how much radioactive debris has settled upon the earth and how much more will probably be added as a result of the nuclear weapons already tested and likely to be tested in the future. Even more effort has gone into researches to learn what proportion of this material will become incorporated in living things and how damaging it will be to plants, animals, and man. In addition to these studies, there have been many arm-chair predictions about the numbers of abnormal infants that will be produced each year, the numbers of people who will die of leukemia and bone tumors, and the numbers of years our lives will be shortened because of radioactive contamination. Some of these predictions have been made by well-known and respected scientists, physicians, and statesmen. Consequently, they have gained wide acceptance, and it is generally believed that thousands of individuals throughout the world are doomed because of the present level of radioactive fallout. It is appropriate at this time to examine critically the bases of these predictions and to analyze some of the available data relevant to the problem of the dangers of small amounts of radioactive materials.

It is not my purpose either to condemn future weapon testing or to nod approval to those who wish to try for bigger and better bombs. Problems in the realm of national policy and international relations must be judged by those who have access to the total necessary information, and the laboratory scientist is not likely to be included in this group. However, the laboratory scientist does have a duty to report the facts as he finds them, and there is a growing body of data upon which an evaluation of the potential hazards of radioactive fallout can be based.

It has been established beyond any possible doubt that irradiation, either from external sources or from radioisotopes within the body, can be dangerous. The manifestations and degree of damage depend upon many factors, such as the type and energy of the rays, the duration of exposure, and the portion of the body involved. In general terms, the major response of the total animal to high levels of irradiation is acute radiation disease and early death. At lower levels, tumor induction and shortening of life are the major signs of damage. In order to assess the dangers of fallout, it is necessary to know what happens at very, very low levels. Such information is completely lacking for man, and it is not easily obtained for experimental animals. Consequently, most predictions have been based upon extrapolations from the effects of higher levels of irradiation. These extrapolations involve two major assumptions. The first is that a linear relationship exists between the size of the dose and the magnitude of the response, so that only a segment of the curve requires experimental verification for accurate projecting of the entire curve. The second assumption is that no dose is so small that it has no effect. Once these premises have been accepted, the task becomes one of collecting all the cases displaying a particular result of irradiation, estimating the doses that produced these cases, and plotting response against dose in such a way that the origin of the extrapolated curve is zero on both scales, as has been done in Fig. 1, curve A. Curve B in Fig. 1 is a variation of curve A with the added complication of "background noise." However, curve C is an equally valid representation of these hypothetical data. Contrary to the other two curves, it assumes that a measureable response does not occur until a certain threshold dose has been exceeded.

The method of thoughtful guessing from a little knowledge is often the only possible approach to a problem, and the answers it provides are useful as long as they are qualified by the uncertainties of the assumptions that were made. However, the fact that many conclusions concerning the dangers of fallout are based upon incomplete data, partial curves, and speculations of this kind is often ignored.

There are other ways of estimating the human hazards of radioactive contamination. The usefulness of animal experimentation was recognized in the early days of the Manhattan Project (*1*), and such investigations have been under way since the products of nuclear fission first became available for biological study. Two major approaches have been used. The first takes advantage of the substantial fund of information on radium poisoning in man. It has assumed that the ratio of toxicities of any radioisotope relative to radium should be approximately the same in the experimental animal and in man if appropriate corrections for differences in retention, life span, size, and other factors are applied. The second approach has involved testing the same isotope in different species. The resulting correlations between toxicity and the various species characteristics then serve as a basis for extrapolation to an animal such as man.

Unfortunately, investigations of the long-term effects of small amounts of toxic agents require a great deal of time, the minimum interval for a complete study being the length of life of the longest survivor. Definitive answers from animal experimentation on fission-product toxicity are not yet available, but the data that have been accumulated during the past 14 years provide a reasonably sound basis for a few predictions about the dangers of human contamination with many radioactive materials. Since the greatest interest now centers around strontium-90 fallout from nuclear weapons, the remainder of this article deals with some of the laboratory data on the toxicity of this isotope. These studies (*2*) are concerned with the effects upon the exposed generation only.

Experimental Rationale and Methods

The most useful criteria of radiation damage to the mammalian organism as a whole are decrease in life span and increase in the incidence of certain tumors. These changes can be accurately meas-

The author is on the staff of Argonne National Laboratory, Lemont, Ill., in the Division of Biological and Medical Research.

ured and evaluated only when large populations are observed during their entire life span. The laboratory mouse is well suited to this type of experimentation because hundreds of animals can be maintained in a relatively small space, and strains with a high degree of genetic and physiologic uniformity can be obtained in large numbers. In addition, since the average mouse lives less than two years, mortality and morbidity data become available within a reasonably short time. However, some of the same characteristics that make the mouse so useful for long-term radiotoxicity studies render direct extrapolation of the data to man impossible. Consequently, information on larger and longer-lived animals is essential to bridge the extreme differences that exist between mouse and man.

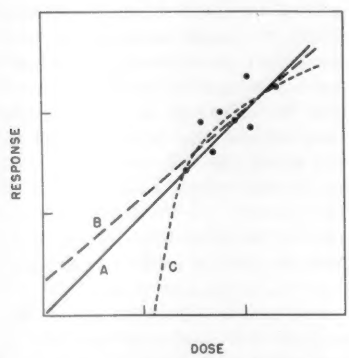


Fig. 1. Possible extrapolations from hypothetical data. (Curve A) This method, the one usually employed, assumes that the origin of the dose-response curve is at zero on both the ordinate and the abcissa. (Curve B) This method also assumes that there is no threshold, but it adds a normal background incidence that prevents an origin at zero on the ordinate. (Curve C) This is an equally acceptable extrapolation from the meager data presented, which assumes that there is a threshold dose that must be exceeded before the response is manifest.

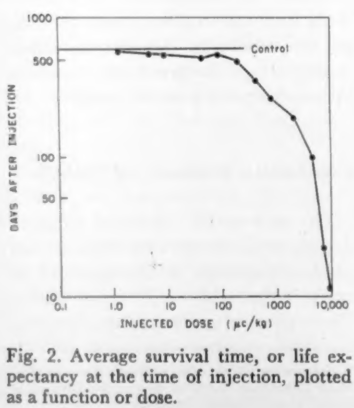


Fig. 2. Average survival time, or life expectancy at the time of injection, plotted as a function or dose.

Human contamination with radiostrontium will occur primarily through ingestion, but the effective dose at low levels is expected to be that which becomes incorporated in the skeleton rather than that which passes through the gastrointestinal tract. Therefore, difficulties in the general application of animal data as a result of interspecific differences in absorption characteristics can be minimized by administering the isotope intravenously. Appropriate corrections based upon absorption factors can then be applied when particular exposure situations are being evaluated. Another difference between human contamination from fallout and animal experimentation with intravenous injection is the length of time during which exposure continues. In the former case the body burden is increased gradually; in the latter case the initial amount of strontium-90 in the body may exceed the amount eventually retained in the skeleton by a factor of 10. Prolonged exposure also leads to a more uniform distribution of radiostrontium within the bones. The effects of both the high initial dose rate and the degree of uniformity of deposition are currently being studied in experiments involving several fractionated dose regimens.

Briefly, then, the mouse is providing basic, statistically reliable information on decrease in life span and increase in the incidence of certain tumors after a single, intravenous injection of strontium-90. These data are being supplemented by mouse experiments in which the route and duration of exposure are varied and by experiments on larger, longer-lived animals, such as cats and dogs.

The plan of the strontium-90 toxicity experiment is given in Table 1. At high levels only a few animals were used, because the effects were expected to appear rapidly and to be unequivocal; at low levels many animals were required, because the effects were expected to appear late, to be less diagnostic of radiation damage, and to require statistical testing. It was intended that the highest dose should reach or exceed the amount necessary to kill 50 percent of the population in 30 days and that the lowest dose should be so low that the treated animals would be indistinguishable from the controls. The lowest injected dose, 1.3 μc/kg, resulted in a body burden of approximately 0.14 μc/kg at 600 days. This is roughly equivalent to 10 μc in a 70-kg man, or to ten times the currently accepted maximum permissible level for personnel engaged in atomic energy work and to 100 times the level set for the general population (*3*).

Young adult female mice (strain CF No. 1) were randomized into the permanent experimental groups 1 week before injection. Dosage was based upon the average weight of the entire population. Postinjection routine included daily observation of all animals and the sacrifice of moribund mice with Nembutal after a peripheral blood sample had been withdrawn. Autopsy was followed by x-ray examination of the entire skeleton and by histologic study of a number of tissues. All organs with grossly visible lesions and all bones with roentgenographically detected abnormalities were added to the tissues regularly taken for histopathology.

Results

In Fig. 2 the average survival time has been plotted against dose on a double-logarithmic grid. At dosages of from 1.3 through 88 μc/kg, the treated animals died, on the average, a little sooner than the control animals, but their deaths were not associated obviously with any particular disease. At dosages of from 200 through 2200 μc/kg, the primary cause of death was neoplastic disease; at higher dosages it was subacute and acute irradiation disease. The values at 1.3, 4.5, and 8.9 μc/kg are not significantly different from the control value. It was calculated that a difference as small as that noted at the lowest dose would be significant at the 1-percent confidence

Table 1. Plan of the strontium-90 toxicity experiment. Female mice, strain CF No. 1, received a single, intravenous injection of an isotonic equilibrium mixture of strontium-90 and yttrium-90 chloride, at *p*H 5 to 6, when they were approximately 70 days old.

Group	No. of animals	Injected dose (μc/kg)	Body burden* (μc/kg)
1	15	9330	1026
2	30	7000	770
3	45	4500	495
4	30	2200	242
5	45	880	97
6	45	440	48
7	60	200	22
8	75	88	9.7
9	90	44	4.8
10	105	8.9	1.0
11	120	4.5	0.5
12	150	1.3	0.14
Control	150	0	0

* The body-burden figures are based upon 11-percent retention at 600 days after injection (*7*), which was the average survival time of the control mice.

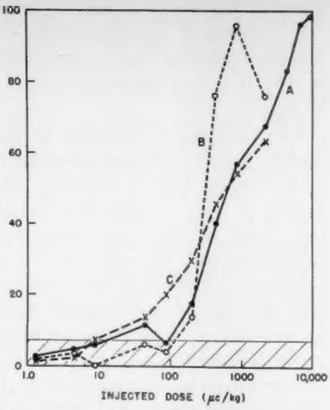


Fig. 3. Effect of strontium-90 on life expectancy and on incidence of tumors of bone and blood-forming tissues. The points within the shaded area are not statistically significantly different from the control values; the shaded area represents nonsignificance at the 10-percent probability level or higher by the *t* test. (Curve A) Percentage decrease in average survival time (life expectancy at start of experiment) compared with average survival time of the controls. (Curve B) incidence of animals with osteogenic sarcomas among 150-day survivors. The incidence among the control population was 2 percent. (Curve C) Percentage decrease in time to a 20-percent incidence of reticular tissue tumors compared with the 20-percent incidence time of the controls.

level if it had been based upon 1393 treated animals compared with the same number of controls, or almost ten times as many mice as were used to establish these points. This calculation, which is based on the assumption of unchanged variability in a larger population, emphasizes one reason why definitive data at very low levels are difficult to obtain. The lowest injected dose that resulted in a statistically significant decrease in life span was 44 μc/kg. These mice had a retained dose of approximately 5 μc/kg, which corresponds to 350 μc per 70-kg man, or to 350 times the maximum permissible body burden for people engaged in atomic energy work and to 3500 times the level set for the general population.

In Fig. 3, curve A illustrates the percentage decrease in average survival time, compared with the average survival time of the control population, plotted against the logarithm of the dose. Even though the animals that received 44 μc/kg showed a statistically significant decrease in life span, those that received 88 μc/kg did not. This peculiar result was due in part to the fact that the two longest survivors in the entire experiment belonged to this group.

Various tumors that might be attributed to strontium-90 appeared in and around bone. There was a pronounced association between dose and both osteogenic sarcomas and hemangioendotheliomas of bone marrow, and there was a suggested association between dose and epidermoid carcinomas of the oral cavity. Fibrosarcomas adjacent to bone and benign skeletal tumors were not influenced by radiostrontium, except insofar as their total incidence was lower at levels that decreased survival time substantially. The proportions of animals that survived the latent period of 150 days and then died with osteogenic sarcomas are shown in Fig. 3, curve B. There were three osteogenic sarcomas among the control mice, an incidence of 2 percent. The lowest injected dose that resulted in a significantly higher number of osteogenic sarcomas was 200 μc/kg. This dose is almost five times larger than the lowest level that resulted in a significant difference in survival. At the next lower dose (88 μc/kg) there were twice as many tumors as in the control group, but the probability that this was due to chance was 30 to 50 percent, as determined by the *t* test. At 44 μc/kg there were three times as many tumors, with a probability of chance occurrence of 20 to 30 percent.

Other neoplasms occurring in the mouse that are influenced by irradiation are those that show certain similarities to the leukemias of man. This group of tumors has been designated by a variety of names, among which are mouse leukemias, lymphomas, lymphoid tumors, thymic tumors, and reticular tissue tumors. They involve the blood-forming tissues, and they arise primarily in the lymph nodes, thymus, spleen, and bone marrow. Although the total incidence of these tumors was not markedly influenced by dose in this experiment, they appeared much earlier among the animals that had received 88 μc/kg or more. Therefore, the data were examined further for evidence of a relationship between dose and time of death with reticular tissue tumors. In curve C, Fig. 3, the percentage decrease in the number of days from injection to the time when 20 percent of the population had died with tumors of the blood-forming tissues is plotted against the logarithm of the dose. The control animals reached a 20-percent incidence 565 days after the beginning of the experiment. The two lowest points on the curve are not significantly different from the control value; the point at 8.9 μc/kg is significant at the 1-percent confidence level. This dose is one-fifth of the lowest dose that produced a significant difference in life span. It resulted in a body burden of approximately 1 μc/kg, which is roughly equivalent to 70 μc/man, or to 70 and 700 times the currently accepted maximum permissible levels for occupational and nonoccupational exposure, respectively.

Linearity and Threshold

In spite of the many differences that exist between mouse and man, it is most likely that the general laws of radiotoxicity that apply to the mouse also apply to man. The experimental data just presented provide the best current information on the shape and origin of the dose-response curve as measured in the total mammalian organism. Since the greatest interest concerns low amounts of irradiation, the data from only the five lowest dose levels have been replotted in Fig. 4 on a rectangular grid in place of the semilogarithmic grid used in Fig. 3. The latter was necessary in order to include the large range of doses in the complete experiment; the former is required for determinations of linearity.

None of the curves in Fig. 4 can be described by a simple linear function. Although the values of the four lowest dosage groups in curve A (reduction in life span) suggest a direct relationship between dose and response, it is not a linear one. Since three of these values

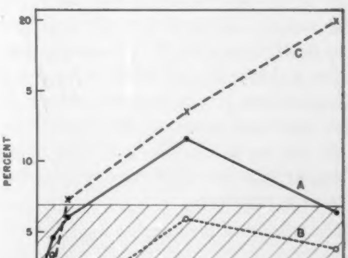


Fig. 4. The relationship of dose and response at low levels. Values above the shaded area are significantly different from the control values. Within the shaded area the probability is 10 percent or greater that there is no difference between the experimental and the control values. (Curve A) Percentage reduction in average survival time. (Curve B) Incidence of animals with osteogenic sarcomas among 150-day survivors. (Curve C) Percentage decrease in time to a 20-percent incidence of reticular tissue tumors.

are not significantly different from the control value, a threshold for the life-shortening effect may lie between 4.5 and 44 μc/kg. However, since the values for 1.3, 4.5, and 8.9 μc/kg do lie along a straight line when plotted semilogarithmically (Fig. 3), it may be argued that they represent true departures from the control value. An extension of this straight line crosses the control value at 0.4 μc/kg.

The incidence of osteogenic sarcomas at these five lowest levels did not extend beyond the statistical limits of the control range, and the data show no trend and no indication of any relationship between dose and response (Fig. 4, curve B). Therefore, a threshold for the induction of these neoplasms in female mice, strain CF No. 1, might lie between 88 and 200 μc/kg. However, since there were two and three times as many tumors among the animals that received 88 and 44 μc/kg, respectively, as there were among the controls, a threshold may actually lie below the latter dose. There were not enough animals at these levels to permit statistical verification of differences as small as those observed.

The three lowest points of the reticular tumor curve that were significantly different from the control value (at 8.9, 44, and 88 μc/kg) do lie along a straight line (Fig. 4, curve C). The values of the two lowest dose levels (1.3 and 4.5 μc/kg), which did not differ significantly from the control value, were examined to determine whether they fell within the statistical range of an extension of this straight line. They were found to lie so far beyond this range that there was no serious likelihood that they belonged to it. If these data do not demonstrate that a threshold dose must be exceeded before there is a measurable change in the course of tumors of the blood-forming tissues in CF No. 1 female mice, they at least show that the dose-response curve is not linear.

Extrapolation to Man

Since it has not been possible to demonstrate a linear relationship between dose and response, the use of straight-line extrapolations from fragmentary human data may be very misleading. In addition, the evidence that there might be a threshold, and consequently a true maximum "indifference dose" for pathologic change as measured in the total animal, raises serious objection to the practice of extending such lines to an origin at zero response and zero dose.

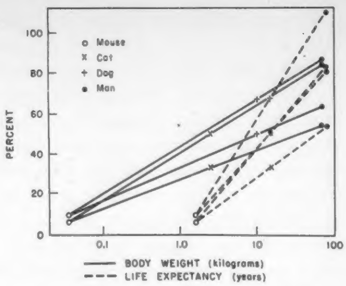


Fig. 5. Estimation of the incidence of osteogenic sarcomas and hemangioendotheliomas of bone marrow in man after an injection of 150 μc of strontium-90 per kilogram. The extrapolations are based upon current data involving mice, cats, and dogs, and they assume a relationship between tumor incidence and body size or life span.

Consequently, other methods of estimating the human hazard from strontium-90 must be used.

Radium method. Comparisons of toxicity ratios with radium as the common denominator between experimental animals and man can be applied as follows. The lowest injected doses that increased the incidence of osteogenic sarcomas in CF No. 1 female mice were 44 μc of strontium-90 and 1.2 μc of radium-226 per kilogram (*4*). This dose of strontium-90 did not significantly increase the incidence of bone tumors related to the controls when evaluated by the *t* test, but since it resulted in the appearance of bone tumors among 6 percent of the treated animals as compared to an incidence of 2 percent among the controls, it was chosen as a probable minimum effective dose. These strontium and radium doses have a ratio of 37 to 1. The largest injected doses tested that did not increase the incidence of osteogenic sarcomas were 8.9 μc of strontium-90 and 0.6 μc of radium-226 per kilogram. This is a ratio of 15 to 1. Thus, at levels in the region of minimum effect, radium is probably somewhere between 15 and 37 times as effectual as strontium-90. In a recently reported series of radium-containing human patients, among those who were probably exposed to relatively pure radium-226 there was one individual with a body burden of 0.4 μc who had minimal but positive roentgenographic evidence of radiation changes (*5*). There were no positive cases at lower levels among those with body burdens uncontaminated with mesothorium, but most of the patients with from 0.5 to 1.0 μc showed similar, minimal lesions. If 0.4 μc of radium represents a dose of minimum effect in man, application of the factors 15 and 37, derived above, results in the estimate that the minimum effective dose of strontium-90 in man is a body burden of from 6 to 15 μc.

The comparative toxicology method. Another approach involves extending the data obtained from a relatively large number of mice, through data obtained from fewer but larger and longer-lived animals, to man. Since the major damage from strontium-90 is due to the energetic beta rays of its yttrium-90 daughter, and since a large proportion of this energy is wasted in an animal as small as a mouse, it is expected that the tumor-producing efficiency of strontium-90 should increase as the size of the animal increases.

The only experiments involving the toxicity of strontium-90 in larger animals that have progressed far enough to be useful for this purpose are two studies including six dogs and six cats that lived more than five months after receiving 150 μc/kg by a single, intravenous injection. Three of the five dogs that have died had osteogenic sarcomas; the sixth is still alive and free of roentgenographic evidence of bone disease. Thus, the final incidence of malignant bone tumors will be 50 or 67 percent. The incidence among mice at the same injected dosage can be estimated to exceed the incidence among the control population by 9 percent. This figure is based upon interpolation between the results obtained at 88 and 200 μc/kg (Fig. 3). When these percentages are plotted against the logarithm of body weight (a 35-g mouse and a 10-kg dog) and extrapolated to a 70-kg man, tumor incidences of 63 and 87 percent are obtained (Fig. 5). When they are plotted against the logarithm of life expectancy (1.6 years for the mouse, 15 years for the dog, and 80 years for man), extrapolation to man gives 80 and 110 percent. These incidences divided by the 9 percent established for the mouse give quotients ranging from 7 to 12. Therefore, strontium-90 might be from 7 to 12 times more effective in man than in mice.

Of the six cats that lived beyond the latent period for tumor induction, two died with osteolytic tumors that have been tentatively diagnosed as hemangioendotheliomas of bone, one died with roentgenographic evidence of the same disease, as yet unverified histologically, and three died free of skeletal malignancies. The incidence of hemangioendotheliomas among mice at 150 μc/kg would be expected to exceed the inci-

dence among the control population by 6 percent on the basis of the incidences at 88 and 200 μc/kg (*6*). The projected incidences for man based upon cats weighing 2.5 kg and having a life expectancy of 15 years range from 54 to 84 percent (Fig. 5). These incidences divided by the 6 percent established for the mouse give quotients of from 9 to 14.

These extrapolations from mice through dogs and cats suggest that strontium-90 is from 7 to 14 times as toxic in man as in mice. The lowest dose that could be shown to have any effect in the mouse was 8.9 μc/kg, which decreased the time interval to the appearance of reticular tissue tumors. This is equivalent to 1 μc retained per kilogram, or to a body burden of 70 μc per 70-kg man. Dividing this dose by the mouse-to-man factor of from 7 to 14 leads to the estimate that the minimum effective dose in man may be a body burden of from 5 to 10 μc of strontium-90.

Danger from Present Fallout Contamination

Perhaps it is merely coincidence that the 6 to 15 μc estimated for the minimum effective dose in man based on the radium method of extrapolation and the 5 to 10 μc estimated from the mouse, dog, and cat data are so similar. In spite of their very tentative nature, these calculations are presented here to illustrate how experimental animal data may be used. In the next few years there should be additional information on radium toxicity in man, since several hundred persons with a possible radium burden are currently under investigation. Consequently, the level of minimum effect will be known with greater exactness. Also, the dog experiments now in progress in several laboratories should provide information over a range of doses so that extrapolations from mouse through dog to man will be possible at more than one level.

The lowest prediction of a harmful dose to man that can be made from the present data attaches significance to the statistically insignificant differences in average survival time at the lowest doses in the mouse experiment. The line passing through these points intersects the control value at an injected dose of 0.4 μc/kg. This dose is equivalent to a retained dose in mice at 600 days of 0.044 μc/kg, or to a body burden in a 70-kg man of 3.08 μc. If the life-shortening factor in going from mouse to man is as great as the estimated tumor-inducing factor—an unlikely assumption for several reasons—a threshold value for man would lie between 0.22 and 0.44 μc of strontium-90. A more likely value is one that lies between 5 and 15 μc, as discussed above. In any case, the present contamination with strontium-90 from fallout is so very much lower than any of these levels that it is extremely unlikely to induce even one bone tumor or one case of leukemia.

References and Notes

1. The Manhattan Project, which developed the atomic bomb, was terminated in 1947. The biological work in progress at that time was continued without interruption under the sponsorship of the newly created Atomic Energy Commission.
2. This work was performed under the auspices of the U.S. Atomic Energy Commission. The views expressed are my own and do not necessarily reflect those of the Biological and Medical Research Division of Argonne National Laboratory.
3. *Natl. Bur. Standards (U.S.) Handbook No. 52* (U.S. Dept. Commerce, Washington, D.C., 1953).
4. M. P. Finkel, *Proc. Soc. Exptl. Biol. Med.* **83**, 494 (1953).
5. W. B. Looney, R. J. Hasterlik, A. M. Brues, E. Skirmont, *Am. J. Roentgenol. Radium Therapy* **73**, 1006 (1955).
6. M. P. Finkel, B. O. Biskis, G. M. Scribner, *Argonne Natl. Lab. Biol. and Med. Research Div. Semiann. Rept. No. ANL-5841*, in press.
7. M. P. Finkel, B. J. Tellekson, J. Lestina, B. O. Biskis, *Argonne Natl. Lab. Biol. and Med. Research Div. Semiann. Rept. No. ANL-5732* (1957), p. 21.

George Sarton, Historian of Science and New Humanist

"Am flying to-morrow morning to Montreal. Vale *G S*" wrote George Sarton on 21 March 1956. He was scheduled to give a lecture in Montreal on 22 March but became ill on the way to the airport and died that day in his Cambridge, Massachusetts, home. Thus, while he was still active and mentally young, the life on earth of this great historian of science came to an end—a life which had begun 72 years earlier, on 31 August 1884 in Ghent, and which had bridged two continents and more, both physically and spiritually.

Death has not ended Sarton's influence. He had continually emphasized the idea that the history of science is not the sum of the histories of the separate sciences but rather their integration, that it is itself a specialty built on a thorough understanding of the methods of science and of history, and that it requires more than the leisure hours of capable scientists or of scholarly historians. He frequently referred to it as a new discipline, and he established it as such in the United States. It bears his mark. Thanks to his persistent pleas, expressed in letters, talks, and published works, and the interest he stimulated, there are now chairs of the history of science and courses or series of courses in that subject in many of our leading universities. Moreover, scholars the world over consult his numerous publications, of which *Isis* and the *Introduction to the History of Science* are the best known (*1*).

George Sarton's early education was obtained first at the Athénée in Ghent and then at that in Chimay. He attended the University of Ghent in the department of philosophy, studied by himself for a year, and returned to the university to study the natural sciences, chemistry and crystallography, and mathematics, in which he received a doctorate in 1911 (*2*).

In 1908 he wrote a chemical memoir (*3*) which gained for him a gold medal offered by the four Belgian universities and a silver laurel branch from the city of Ghent. In these early years he also wrote romantic books and poems (*4*), an exercise which contributed to the development of his eminently readable prose.

Influenced by the writings of Comte, Tannery, Duhem, Poincaré, and others, while he studied pure science, Sarton grew increasingly more interested in the history and philosophy of science. He came to believe that the basis of all

scientific philosophy was the history of science, and by the close of 1912 had determined to devote his life to establishing it as an independent discipline on the same plane with the other scientific disciplines. On it would be focused the history of mankind, because the only human activities which Sarton considered cumulative and progressive are the scientific ones.

In 1911 he had married an English artist. The young couple bought a home at Wondelgem, near Ghent, and there, in 1912, a daughter was born. Sarton's wife was the ideal helpmate. She quietly bore the brunt of their economic difficulties and never complained. Back of George Sarton's dedication to the history of science was Eleanor Mabel Elwes Sarton's dedication to her husband.

In Wondelgem Sarton accumulated notes on the history of science and launched *Isis*, a journal devoted to that subject. The first issue appeared in March 1913. But World War I destroyed the even tenor of the days. After packing the notes in a small metal trunk and burying them in the garden late at night, the Sarton family fled before war's horrors—across the border into Holland and on to England. In 1915 they came to the United States.

The first years in the New World were hard ones. It would not have been difficult to earn a living as a teacher of mathematics or of science or of French. Yet, although he was continually short of funds, it never occurred to Sarton or to his wife that he should earn money otherwise than by teaching the history of science. It was for that purpose that he had come.

A group of Harvard friends collected a small sum of money which they gave to the university to enable Sarton to spend two years in research and teaching. In addition, he delivered the Lowell lectures in Boston. In August 1918 he became research associate of the Carnegie Institution of Washington and chose to live in Cambridge, Massachusetts, with the great Widener Library for use as though it were his own. His offer to give a course in the history of science at Harvard in exchange for a separate room in the library was accepted in 1920, and in 1940 he was named professor.

Volume 2 of *Isis*, begun in June 1914, was completed in September 1919. A trip to Belgium to make the necessary arrangements with the printers was the occasion for the joyful recovery of his buried notes and of a large portion of his library.

Sarton described *Isis* as one result of a philosophical reaction to the analytical trends of 19th-century science (*5*). From its very inception *Isis* was intended as the organ of the new discipline. Its name was chosen because it evoked "the period of human civilization which is perhaps the most impressive of all,—its beginning" (*6*) and because the title of a review should be as short as possible. It was to be a synthetic, critical, international, and, in a sense, dogmatic review of the sciences from the historical, philosophical point of view, studying their evolution and logical sequence and less concerned with the science of the present than with that of the past (*7*). Beyond this, *Isis* was to have a mission—to underline the lessons of tolerance and wisdom which history presents. It was to denounce the imperialistic tendencies which Sarton found some scholars trying to impress on the science of their country or their race (*8*). It was to be more a philosophical and sociological review than a collection of historical erudition. One or more articles by Sarton in every issue set the tone.

Among the most important features of *Isis* are the "critical bibliographies," of which the last under Sarton's direction appeared in volume 44 (1953). There he wrote, "The seventy-nine bibliographies edited by me contain over 100,000 notes, many of which are short reviews. I must have written an average of seven such notes per day for 15,000 consecutive days almost without respite." A scholar who starts a topic in some aspect of the history of science without consulting the critical bibliographies is treading on thin ice!

On 12 January 1924 the History of Science Society was founded, primarily to guarantee and promote the publication of *Isis*. But Sarton remained the editor and, until 1941, was financially responsible for it. In 1953, I. Bernard Cohen, who had been managing editor for a number of years, became editor, and Sarton at last felt free to devote himself to his planned *A History of Science*, which was to be the reworking of his course lectures. Only the first volume, *Ancient Science in the Golden Age of Greece* (1952), appeared in his lifetime.

In 1936, to relieve *Isis* of the load of longer papers too short to appear separately but deserving publication, another periodical, named *Osiris*, was founded. It was never supported by the History of Science Society, but solely by Sarton.

Sarton had a capacity for friendship and a humility about his own place in the world. Sometimes this humility took on the air of preaching, but if this manner is accepted in the sense in which it was intended, it only enhances Sarton's stature. His attitude of preaching is partly the mark of a teacher but also reflects his deep disturbance over changes occurring in the world. Sometimes he was bitter about the attitudes adopted by people; sometimes he spoke against wealth, stressing its unimportance. In 1938 he wrote, "The German atrocities are terrible; they make me ashamed of being a man!" (*9*). But in 1944 he seemed happy when he wrote "My 60th birthday was admirably celebrated—first with a magnificent Festschrift . . .,—second (even better) with the liberation of my native country and the end of a terrible nightmare" (*10*). On Christmas 1951 he added, "What we need above all is Peace" (*11*).

He had the ability to boil down a statement, to restate material in simpler terms, making a comparison with something familiar to his audience, without ever being too glib or too flippant. His method of drawing analogies is characteristic of his authorship. He had no tolerance for inaccuracies. He was tireless in his own application and expected others to exercise the same patience and critical attitude in their work.

Although Sarton was fully aware that we are living in a changed world, one that has changed more in the 20th century than in all the preceding ages, he had reverence for the old because all that he found best in the world is very old—the things which add meaning to our life, such as charity, the love of truth, religion, art, all the graces of life. He stressed the value of quiet study and meditation, for to be intellectually sound one must leave space in life for these. As a young man he was a frequent concertgoer, and later he accumulated a delightful library of recorded music. All his life he saw beauty about him, and his travels gave him the opportunity to visit the beauty spots of the world and drink them in.

For George Sarton science was "the totality of positive knowledge" (*12*, p. 118). He expressed himself as follows: "*Definition*. Science is systematized positive knowledge, or what has been taken as such at different ages and in different places. *Theorem*. The acquisition and systematization of positive knowledge are the only human activities which are truly cumulative and progressive. *Corollary*. The history of science is the only

history which can illustrate the progress of mankind. In fact, progress has no definite and unquestionable meaning in other fields than the field of science" (*13*). This may not be everyone's definition of science or everyone's view of the history of science, but it was the foundation on which Sarton built. Whereas he considered scientific method the most elaborate discipline of thought ever conceived, he did not consider it all-sufficient. It is inapplicable to art, religion, and morality and may always remain so. Furthermore, he dreaded its possible misapplications.

Sarton's history of science, an all-embracing picture of the impact of scientific progress on mankind and the effect on science of man's environment, was a means, not an end. The end was the philosophy of science. He felt that the history of science should make us less conceited about our share in total human evolution. It, alone, can give us a clear and complete consciousness of the advancements of modern science and will permit us to appreciate its real significance. Since the past interests only because of the future, and acquires all its real significance only in the light of the present (*14*), the historian of science must be alert to the scientific problems of today. As Sarton put it: "The chief requisite for the making of a good chicken pie is chicken; nay, no amount of culinary legerdemain can make up for the lack of chicken. In the same way, the chief requisite for the history of science is intimate scientific knowledge; no amount of philosophic legerdemain can make up for its absence" (*15*).

The history of ancient and medieval science is as useful and necessary as that of modern science, but not all historians of science need study the whole. A study of any special branch gains in technical richness what it loses in regard to the larger subject. Subdivisions lead to a better understanding of periods which require special techniques (*16*). The historian of science must be grounded in historical facts as well as in scientific ones and be familiar with the methods by which these two kinds of facts are obtained and interpreted (*17*). Sarton believed in joining the biographical side of the history of science with the history of ideas (*18*, p. 33). A man must be examined entire. Nor can one stop with the achievements of the outstanding men because the final results in science are independent of their discoverers (*19*, p. 99) and because, in the gradual preparation of any discovery, a number of smaller ones usually figured (*18*, pp. 21–22).

The George Sarton medal. Sarton was the first recipient of the medal. The award was made on 29 December 1955 at a luncheon at the Mayflower Hotel, Washington, D.C., during the annual meetings of the History of Science Society, held in conjunction with the American Historical Association. The medal was made possible by a generous gift from Chas Pfizer and Company, Inc.

After delivering his Lowell lectures, devoted to Leonardo da Vinci, Sarton felt that he must make a thorough survey of the ancient and medieval science leading to Leonardo. It was then that he formally planned his *Introduction* (*20*, *21*). Thanks to the recovery of his notes and library, he was able to begin the writing in January 1921. Each chapter contains the summary of a period, followed by a detailed analysis of the work of the individuals in that period, complete with invaluable bibliographical information. The fundamental purpose of the *Introduction* was "to establish the history of science as an independent and organized discipline," to define this study, and to show the importance thereof, not only for the philosophy of science but for any positive philosophy (*22*). It and *Isis* did just that. With the 14th century, five centuries short of his goal and a half-century short of Leonardo, Sarton stopped his *Introduction* in order to devote his remaining years to writing the shorter books which had been slowly maturing in his mind (**21**, vol. 3, p. 5).

The emphasis on the human side of science which is apparent throughout the Sarton writings is the result of a continuous effort to humanize science, to integrate it with the other elements of our culture, to inject into it a little of the historical spirit, of reverence for the past. The Old Humanists were concerned only with the classical arts and letters and their derivatives in Europe and could hardly conceive that scientific efforts had any other value than their enormous utilitarian and financial one. The New Humanism was, so to speak, built around science. The history of science was the bridge between the old humanist and the scientist, and the construction of that bridge was deemed by Sarton to be our main cultural need (*18*, pp. 57–58).

Sarton's humanist had to explore and defend the ideals of Eastern peoples as well as those of the West and to show that the writings of classical antiquity and of the Old Testament are not the only writings deserving consideration; that their tradition would not have survived or would have been delayed without Arabic intervention.

Convinced that Oriental studies were necessary to develop the whole man, to picture the whole civilization, to integrate the past and the present of science with the arts and religions, Sarton spent six months in the East studying Arabic, and countless hours, in the next 20 years, at home perfecting his knowledge of this language and the culture to which it was a gateway. He corresponded in Arabic with numerous Eastern scholars. He was not going off on a tangent. He was digging deep. He aimed to show the immense contribution of Eastern people to our civilization. The history of science begins in the Middle East (*23*). Later, the medieval Arabic-speaking peoples added to the Greek heritage before handing it over to their Latin successors. The creation, or slow incubation, of the experimental spirit, of which we hear so much in the 20th century, was the main and least obvious achievement of the Middle Ages, first primarily due to the Muslims, then to the Christians (*19*, pp. 99–100). From the middle of the 8th to the end of the 11th century, Arabic-speaking peoples, including some Jews and Christians, marched at the head of mankind, and their language became the international language of science.

The study of the history of science presupposes teachers of that discipline and its inclusion in the curriculum. Sarton outlined in detail both general and special courses in the history of science and the qualifications of the teachers. They must have a firsthand knowledge of science. He explained the value of experiments performed in classes. Harvard's natural science courses are now given in a lecture room equipped for showing experiments illustrating the history of science.

Sarton stressed the study of languages. This must begin with a thorough understanding of one's own. It is generally agreed that a practical knowledge of Greek and Latin is prerequisite to the original study of ancient science. He thought it equally true, although less obvious, that some knowledge of Arabic and even of Hebrew is necessary to a complete understanding of medieval science (*24*). He saw no need for the creation of an artificial language or for the adoption of an international one. *Isis* recognized six languages as international: English, French, German, Italian, Latin and Spanish (*25*). Scholars who wish to be read should write in one of these (*26*). Sarton saw no reason for the United States libraries to subscribe to journals written in what he called the "small" languages, but thought one of the libraries should try to collect all the material in a given tongue, another should concentrate on a different one.

Charles Singer calls Sarton "one of the great teachers of our age" (*27*). This is because he was a superb organizer of knowledge and an integrator. In addition he had a powerful personality. Students thronged his lecture classes. But he was not quite so successful with individual graduate students, partly because he was frequently bitter about the state of the world and held the fate of individuals to be of little consequence in terms of the whole of mankind. This seems inevitable for one whose life was so altered by political events. He was impatient to get on with what he considered the more important tasks. I, myself, found him unstinting of his time, his energy, his advice, and his encouragement. In 1929, when I asked to study under him, he wrote, "I am afraid we shall not be able to get around Radcliffe's regulations" (*28*). But he wrote to the secretary of that college, "It is true that no A.M. degree has ever been granted by Radcliffe in that subject [history of science], but I cannot consider that as a preemptory argument. I am sure you will be at one with me in hoping that Radcliffe will do many things in the future that it has never done before" (*29*). His plea was successful.

He never considered courses satisfactory advanced training in the field. Following them "is but a poor method & the sooner you can wean yourself from it, the better for you.—The only way to train yourself as a historian is to carry on historical investigations under expert guidance" (*30*). This expert guidance is what he provided to a fortunate few in his office, with the whole of Widener Library as a laboratory. And there one learned that even working with a gifted teacher is not sufficient; it is the actual doing which matters. Run down every reference, read every footnote, seek the original version, and do it yourself. Check everything, document everything, and provide an index.

A man such as Sarton was bound to ripen with the years. When he changed his opinion he did not hesitate to say so. For example, in the second volume of *A History of Science,* (*31*) he altered the dates he had previously assigned to some men of antiquity and to the Dead Sea scrolls. Years of research changed his estimate of the Renaissance. In 1929 he said, "If one excepts the extraordinary climax which occurred toward the end of that period, in 1543, the Renaissance was less a genuine revival than a halfway rest between two revivals" (*32*). The first of these, beginning in the second half of the 11th century and culminating in the 13th, was stimulated by the introduction of Greco-Arabic knowledge into Western Europe; the second began with the development of the experimental method in the 17th century. The day before his death Sarton wrote, "My statement of 1929 has been somewhat toned down in my Appreciation (Philadelphia 1955) and will be further corrected in Six Wings. . . ." In the former he emphasized what he considered the role of the Renaissance in "the slow metamorphosis of ancient and medieval traditions into modern ones" (*33*, p. 132). He announced his interpretation of the period as both a revival of antiquity and a discovery of something new, and he carefully examined "Renaissance awareness and knowledge of the old scientific classics as revealed by the incunabula and the sixteenth-century books" (*33*, p. 6). He described the work of hundreds of individuals who, between 1450 and 1600, revived the old, or pointed out new directions in science. In *Six Wings: Men of Science in the Renaissance* (*34*), rather than focusing on the retention, reintroduction, or reinterpretation of past science, he emphasized the men of science of the period. In this way he showed Renaissance science as a part of Renaissance life. In his last work (*31*) he made allusion to "Renaissance minds," spoke of a certain book as "a monument of the French language of the Renaissance," and made a distinction between what scholars of the Renaissance could, and what we no longer can, appreciate. In other words, his change of view was incorporated into his general thinking. In the latter part of his life he was not as dogmatic as in his youth, when he had staunchly supported the belief that the history of science was the only proper approach to the past. He came to realize that the history of religions, the history of arts and crafts, the history of laws and institutions is each an avenue of approach (*35*).

By his lectures, books, and articles, as well as through his students and his colleagues throughout the world, George Sarton spread his interpretation of the history of science. The path he pointed out will not soon be forgotten.

C. Doris Hellman

Pratt Institute, Brooklyn, New York

References and Notes

1. "The George Sarton Memorial Issue" of *Isis* [48 (Sept. 1957)] contains a complete bibliography of Sarton's writings as well as articles about him.
2. G. Sarton, doctoral dissertation, "Les principes de la mécanique de Newton" (manuscript, 130 pp.).
3. ———, "Etude d'un phénomène d'autocatalyse négative en système hétérogène, précédée d'une étude théorique sur la catalyse, l'autocatalyse et la catalyse négative (manuscript, 75 pp.).
4. See K. Strelsky, "Bibliography of the Publications of George Sarton," *Isis* 48, 337 (1957).
5. G. Sarton, *Isis* 1, 5–6 (1913).
6. ———, *ibid.* 6, 39 (1924).
7. ———, *ibid.* 1, 42 (1913).
8. ———, *ibid.* 1, 44 (1913).
9. ———, postal card, 13 Nov. 1938.
10. ———, letter, 15 Oct. 1944.
11. ———, letter, 25 Dec. 1951.
12. ———, *The History of Science and the New Humanism* (Braziller, New York, new ed., 1956) (first published in 1931).
13. ———, *The Study of the History of Science* (Dover, New York, new ed., 1957) (bound with *The Study of the History of Mathematics* but first published in 1936), p. 5.
14. ———, *Isis* 1, 193–96 (1913).
15. ———, *Sci. Monthly* 7, 194 (1918).
16. ———, *Isis* 13, 274–75 (1930).
17. ———, *ibid.* 4, 233 (1922).
18. ———, "The History of Science and the History of Civilization," in *The History of Science and the New Humanism* (*12*).
19. ———, "East and West" (first published in 1930), in *The History of Science and the New* Humanism (*12*).
20. ———, *Osiris* 11, 111 (1954).
21. ———, *Introduction to the History of Science* (Williams and Wilkins, Baltimore, Md., for the Carnegie Institution of Washington; vol. 1, 1927; vol. 2, in two parts, 1931; vol. 3, in two parts, 1947–48).
22. ———, *Isis* 4, 23–25 (1921).
23. ———, *The Incubation of Western Culture in the Middle East* (Library of Congress, Washington, D.C., 1951), p. 10.
24. ———, *Isis* 13, 275 (1930).
25. ———, *ibid.* 39, 10 (1948).
26. ———, letter, 10 Jan. 1951.
27. C. Singer, *Nature* 178, 67 (1956).
28. G. Sarton, letter, 29 Nov. 1929.
29. ———, letter, 4 Dec. 1929.
30. ———, letter, 19 Apr. 1929.
31. ———, *A History of Science: Hellenistic Science and Culture in the Last Three Centuries B.C.* (Harvard Univ. Press, Cambridge, Mass., in press).
32. ———, "Science in the Renaissance," in *The Civilization of the Renaissance* (Univ. of Chicago Press, Chicago, Ill., 1929), p. 75.
33. ———, *The Appreciation of Ancient and Medieval Science During the Renaissance* (1450–1600) (Univ. of Pennsylvania Press, Philadelphia, 1955).
34. ———, *Six Wings: Men of Science in the Renaissance* (Indiana Univ. Press, Bloomington, 1957).
35. ———, *Horus: A Guide to the History of Science . . .* (Chronica Botanica, Waltham, Mass., 1952), p. 10.

News of Science

Consultant and Clearing House Service on Academically Talented

The National Education Association has announced the establishment of a consultant and clearing house service on education of the academically talented. Charles E. Bish, former principal of McKinley High School, Washington, D.C., has been named director of the 3-year project, which will collect information on such questions as: How can specific schools most effectively educate their talented students? What have experiments revealed on various methods? How can the teacher, guidance counselor, and school administrator cooperate? What is necessary in the way of teachers and equipment?

The new service will be carried on under the administration of the NEA and its appropriate units through a grant from the Carnegie Corporation. Chief concern of this project will be the academic subjects in the secondary schools. The new center will (i) provide consultant service to state and local school systems, to colleges and universities, and to local, state, and national education associations; (ii) keep an up-to-date record of experimental and research projects; (iii) develop a comprehensive collection of materials on all aspects of the problem; (iv) develop plans for needed research; and (v) organize study conferences on specialized topics within the field.

This much-needed service will assemble the results of research studies and other programs now carried on in various parts of the country and by numerous organizations. For the first time, those educators collecting information and those seeking it, will have a reliable and continuing point of contact.

The new service is a follow-up of the project carried on during the current year dealing with the identification and education of the academically talented pupil in the secondary school. A nationwide conference held last February under the chairmanship of James B. Conant, president emeritus of Harvard University and former ambassador to the Federal Republic of Germany, climaxed the earlier project. That conference, also financed by the Carnegie Corporation, brought forth recommendations published by NEA and widely circulated throughout the country. Inquiries should be directed to: Dr. Charles E. Bish, Director, Project on the Academically Talented Pupil, National Education Association, 1201 16th St., N.W., Washington 4, D.C.

Soviet Dogs Ascend 281 Miles

The Soviet News Agency Tass has reported that the U.S.S.R. sent two dogs up in a rocket to an altitude of 281 miles and returned them safely to earth. It is not clear whether or not the dogs remained in the rocket during ascent and descent or whether, as in earlier experiments, they were parachuted to earth in a hermetically sealed compartment. The highest altitude reached in previous Soviet experiments with animals that were returned was 132.5 miles.

A single-stage rocket was used. It pushed a load of 1690 kilograms (about 3718 pounds) to the 281 mile altitude. The weight was about 800 pounds more than that of Sputnik III.

U.S. research. The United States has tried three times this year to recover mice sent aloft in Thor-Able missiles. Search teams were unable to find the mice-carrying nose cones after they had fallen into the South Atlantic. However, data radioed from two missiles that had flown the prescribed trajectory indicated that the animals had survived the acceleration to 600 miles and the deceleration encountered on reentering the atmosphere.

In 1952, the United States sent two monkeys and two mice to an altitude of 36 miles in an Aerobee rocket. They survived.

Regional Census Training Center

A regional Census Training Center for Asia and the Far East opened 1 September in Tokyo under the sponsorship of the United Nations and the Food and Agriculture Organization of the United Nations, in cooperation with the Government of Japan. The Training Center, which will last until 13 December, will include some 50 participants from the following countries and territories: Afghanistan, Burma, Ceylon, China (Taiwan), Federation of Malaya, India, Indonesia, Iran, Korea, Laos, Nepal, North Borneo, Pakistan, Philippines, Ryukyu Islands, and Thailand.

Governments were asked to nominate as participants in the training center officials who are to be responsible in their countries for major technical phases of the world census which is planned for 1960. The director of the center is Seiichi Tobata, president of the Agriculture, Forestry and Fisheries Council, Ministry of Agriculture and Forestry, Japan; the co-director is Octavio Cabello, who is in charge of social statistics in the United Nations Statistical Office.

Censuses of population, housing and agriculture are of basic importance to the planning of economic and social development. However, it is important to obtain a reasonable degree of comparability in the censuses. To provide census assistance to governments, the United Nations and FAO are making regional teams of experts available on request. These teams will help governments in organizing regional training centers to deal with all aspects of census operations. The Tokyo center is devoted to the actual planning and organization of censuses. Training will be offered in 1959 or 1960 on the analysis, evaluation, and use of census results.

Army Research Office

The new Army Research Office, located at Arlington Hall Station, Arlington, Va., was established in March of this year for the purpose of promoting and coordinating the growing Army research effort in physical, engineering, geophysical, biological, medical, and social sciences. It is in communication with the nation's scientific community to obtain new ideas, approaches, and techniques which can be used in the Army's Research and Development Program. It also guides the efforts of the Army's seven Technical Services, which continue to direct actual research projects in their respective fields.

It functions as an integral part of the Army's Office of the Chief of Research and Development, and in this respect it differs from both the Office of Naval Research and the Air Force Office of Scientific Research, which operate as organizations separate from their respective staffs. The ARO method of operation is designed to fill the particular needs of the Army structure and to exploit the strength of its Technical Services, which will continue to make increasing use of research capabilities of private industry, universities, and nonprofit organizations.

Generally, in the Army, the develop-

ment of a particular item is done by a single Technical Service or private contractor. Research, however, being diffuse by its very nature, may cut across several technical service or private industry lines, and offer promise to several different Army organizations or programs.

The ARO, in this situation, will provide centralized planning and coordination of an Army-wide research program, for Army-wide benefit. Planning will be centralized in ARO; execution will be decentralized. Research projects will continue to be handled by the Technical Services, using either their own facilities or those outside the Army, with the exception of a few projects of Army-wide nature. The Technical Services will retain complete control over their laboratories.

The Army's seven Technical Services are the Army Medical Services, the Ordnance Corps, the Corps of Engineers, the Quartermaster Corps, the Transportation Corps, the Signal Corps, and the Chemical Corps.

The ARO staff now includes 57 persons, mostly military and civilian scientists, with necessary administrative personnel. Its program extends over some 2000 research tasks, with a yearly expenditure of about $90 million. The staff will be increased to 85 persons by mid-1959 to give the program the direction it requires. ARO is now recruiting these additional personnel, principally civilian scientists in the upper-pay grades.

Sardis Found

Archeologists from Cornell and Harvard Universities have located the site of the ancient Lydian city of Sardis, once the capital of King Croesus. Ruins of the city were found beneath those of a Roman city that was uncovered earlier this summer in Turkey near the Izmir-Sahihli highway. The discovery, climax of 2 months of searching, came just a few days before the Cornell–Harvard group was due to leave the excavation site for the United States.

Sardis was the capital of Lydia in the sixth century before Christ and was one of the foremost cities of the ancient world. Croesus was the last of the Lydian monarchs to reign at Sardis. During Roman times it was the seat of a Christian bishop and was one of the "seven churches which are in Asia" mentioned in the Book of Revelation.

The expedition was sponsored by Cornell University, the Fogg Art Museum of Harvard University and the American Schools of Oriental Research, with the support of the Bollinger Foundation of New York City. The excavations will be carried out over a 3-year period. George M. A. Hanfmann of Harvard was the expedition's field director, and A. H. Detweiler of Cornell, field adviser. Other group members were Sherman E. Johnson, M. D. Ross, and John Washeba.

Nuclear Test Program

John A. McCone, chairman of the Atomic Energy Commission, and Neil H. McElroy, Secretary of Defense, have announced plans for the final nuclear test series that will take place prior to the suspension of tests for 1 year, starting 31 October. The 1958 test program, which has been in progress at the Eniwetok Proving Ground and Johnston Island in the Pacific, will conclude with approximately ten low-yield nuclear detonations at the Nevada Test Site during September and October.

Several of the test shots will take place underground in tunnels that have been under construction for several months; the remainder will be fired from balloons or towers. More than half of the tests will be less than one kiloton; the highest yield will be in the nominal (20 kiloton) range. Certain information of interest to seismologists will be provided in advance of the underground detonations.

Solar Energy Research

The Curtiss–Wright Corporation and New York University have announced joint and separate programs for research, development, and practical application of solar energy to be carried out at the Princeton Division of Curtiss–Wright, Princeton, N.J. All the programs will be under the direction of Maria Telkes, who has been in charge of solar energy research at N.Y.U. since 1953.

Curtiss–Wright is entering the field of solar energy with immediate emphasis on the development and production of commercially saleable solar products, based upon existing patents, knowledge and needs. It is anticipated that New York University's participation in the joint program will generate new and basic discoveries.

The new industry-university program includes the establishment at Princeton of the New York University Solar Research Laboratory to serve as a center for teaching, research, and the dissemination of knowledge. Curtiss–Wright, among other companies, will provide grants for research projects. Curtiss–Wright will also provide a building to house the N.Y.U. Solar Research Laboratory staff of scientists and technicians and will make other facilities available.

Cooperation with Curtiss–Wright in solar energy will be only one phase of New York University's solar program. The N.Y.U. Solar Research Laboratory will limit its activities to academic-type research and will not develop properties and patent rights for the university. It will, however, continue to conduct separate research and development programs with commercial organizations and government agencies.

A complete Sun Court and Solar Laboratory is now under construction by Curtiss–Wright at its Princeton Division, where solar products will be produced. The Sun Court includes a solar heated house and a solar heated swimming pool, solar furnaces, solar batteries, solar stills, solar driers, solar cooking equipment, solar radios, and solar food processing equipment.

Bathyscaphe

The U.S. Navy has acquired the bathyscaphe *Trieste,* launched by Auguste Piccard and his son Jacques in 1953. Last summer the Navy rented the craft for research dives off Capri, Italy, and recently bought it from the Piccards for $200,000. A new one would probably have cost $1,500,000. Already *Trieste,* which is described in the 1 September issue of *Time,* has descended almost 3 miles, or twenty times deeper than conventional submarines. It can do this without danger to itself or passengers because it operates under water like a blimp. Its 50-foot hull is a float carrying 28,000 gallons of gasoline, which is 30 percent lighter than sea water and compressible. The float does the job of a balloon's gas-filled bag, while the passenger ball hangs below. Water enters the float, equalizes the inside and outside pressure, and compresses the gasoline, reducing the craft's buoyancy. Next month *Trieste* will begin diving off San Diego, Calif., to study the ocean's physical, biological, geological and chemical characteristics.

FAO World Livestock Disease Reporting Service

The Food and Agricultural Organization has established a world livestock disease reporting service that will operate from FAO headquarters in Rome. The service has been developed in collaboration with the International Office of Epizootics. Information will be gathered from the reporting forms issued to FAO and OIE member governments. This form, which has been revised and improved, was first circulated in 1957 and, as a result, a preliminary report on world livestock disease has been issued for 1956.

FAO plans to publish annually a *Yearbook of Animal Disease* that is ex-

pected to provide an over-all picture of animal diseases of major economic importance and of methods of control throughout the world. The yearbook will be particularly useful to veterinary authorities when imports of animals and animal products are being considered.

Pharmacological Journals

Three new journals in the rapidly growing field of pharmacology are appearing. *Biochemical Pharmacology,* an international journal devoted to research into the development of biologically active substances and their mode of action at the biochemical and subcellular level, is edited by a board of which Alexander Haddow of the Chester Beatty Research Institute is chairman. The regional editor for the United States is A. D. Welch of Yale University. The publisher is the Pergamon Press, New York and London. The first volume appeared in July.

Academic Press, Inc., of New York City, has announced the publication of *Toxicology and Applied Pharmacology,* with H. W. Hays of the National Research Council as managing editor, assisted by Frederick Coulston of the Sterling-Winthrop Institute and Arnold J. Lehman of the Food and Drug Administration. The first number is to appear in January 1959.

Interscience Publishers of New York City has announced an international bimonthly periodical, *Journal of Medicinal and Pharmaceutical Chemistry,* the first issue to appear toward the end of the year. This will have as editors Arnold H. Beckett of the Chelsea College of Science and Technology, London, and Alfred Berger of the University of Virginia.

Physics Course on TV

In an attempt to raise the standards of physics teaching in all sections of the United States, a nationwide college course in atomic age physics will be televised over the National Broadcasting Company network for two semesters, beginning 6 October and continuing through 5 June. Designed primarily for high school science teachers, the program will be known as the "Continental Classroom."

The course, to be offered for credit through the auspices of local colleges and universities, will be telecast from 6:30 to 7 A.M. (in each time zone) Monday through Friday. This is probably the first time that a course for college credit has been offered on a nationwide basis.

Harvey E. White, professor and vice-chairman of the department of physics at the University of California in Berkeley, will be responsible for the course. Other internationally known scientists will serve as guest lecturers.

Sponsors of the new program include the American Association of Colleges for Teacher Education, the Fund for the Advancement of Education, and N.B.C. Consultants for the series include Mark Zemansky, chairman of the department of physics at City College of New York; Henry Semat, professor of physics at C.C.N.Y.; and Vernet E. Eaton, professor of physics at Wesleyan University, Middletown, Conn.

Grants, Fellowships and Awards

Radiological research. On behalf of the James Picker Foundation, The National Academy of Sciences–National Research Council announces the continued availability of funds in support of radiological research. Applications are reviewed by the Committee on Radiology of the Academy-Research Council's Division of Medical Sciences. Final determination of awards is made by the foundation upon recommendation of the division.

In line with the interests of the foundation, the program is oriented toward, but not necessarily limited to, the diagnostic aspects of radiology. Support is not restricted to citizens of the United States or to laboratories within this country.

Three specific types of support are offered:

(1) Grants-in-aid are designed to encourage investigations offering promise of improvement in radiological methods of diagnosis or treatment of disease. Research grants are awarded to institutions, rather than to individuals.

(2) Grants for scholars are a transitional form of support, designed to bridge the gap between the completion of fellowship training and the period when the young scientist has thoroughly demonstrated his competence as an independent investigator. The application is submitted by the institution on behalf of the prospective scholar. If the request is approved, a grant of $6000 per year will be made directly to the institution as a contribution toward the scholar's support, or his research, or both. Initial grants are limited to 1 year, but renewal for two additional years may be recommended.

(3) Fellowships in radiological research are open to candidates seeking to gain research skills leading to investigative careers in the field of radiology. While persons from closely related disciplines are eligible to apply, candidates whose training has been directly in the field of radiology will receive preference under this program. Candidates must hold the M.D., Ph.D., or Sc.D. degree or the equivalent. Preference will be given to applicants who are 35 years of age or less.

Applications in these three categories for the fiscal year 1959–1960 should be submitted by *1 December 1958.* Further details and application blanks may be obtained from the Division of Medical Sciences, National Academy of Sciences–National Research Council, 2101 Constitution Ave., NW, Washington 25, D.C.

The National Research Council of Canada has assumed the responsibility for serving as scientific adviser to the James Picker Foundation with respect to its Canadian program. Applications for support of studies to be carried out in Canada should therefore be directed to the Awards Office, National Research Council of Canada, Ottawa 2, Canada.

Scientists in the News

President Eisenhower has selected four more members of the civilian space agency council, completing the membership for the nine-man group, which he heads. The new appointees are Lieutenant General JAMES H. DOOLITTLE (ret.), vice president of the Shell Oil Company and chairman of the National Advisory Committee for Aeronautics; WILLIAM A. M. BURDEN of New York, who in 1943–47 was Assistant Secretary of Commerce for Air and who served in 1950–52 as a special research and development assistant to the Secretary of the Air Force; ALAN T. WATERMAN, director of the National Science Foundation; and DETLEV W. BRONK, president of the National Academy of Sciences and also head of the Rockefeller Institute of Medical Research.

Other members of the council are: John Foster Dulles, Secretary of State; Neil H. McElroy, Secretary of Defense; T. Keith Glennan, chief of the new Space Agency; and John A. McCone, chairman of the Atomic Energy Commission.

JOSEPH J. PFIFFNER, specialist in the biochemistry of vitamins and hormones, has been appointed professor of physiology and pharmacolgy at Wayne State University College of Medicine. For the past 21 years, Pfiffner has been associated with Parke, Davis and Company, where he has been laboratory director in biochemical research since 1951.

ALLEN J. SPROW, executive editor of *Psychological Abstracts* and treasurer of the National Federation of Science Abstracting and Indexing Services, has resigned to become bibliographer and an

editor of *Biological Abstracts.* This position, a new one on the staff of *Biological Abstracts,* has been created to ensure the optimum coverage of the periodical literature of biology through continuing bibliographic studies. In addition to this research responsibility, Sprow will be in charge of the literature procurement and records department.

ROGER REVELLE, director of the University of California's Scripps Institution of Oceanography, has been given the additional responsibility of director of the university's new Institute of Technology and Engineering. The institute was established by the regents in July to provide graduate instruction and research in mathematics, physics, chemistry, the earth and biological sciences, and engineering. It will be located at La Jolla.

GEORGE S. BONN has been appointed chief of the Science and Technology Division of the New York Public Library, effective 1 October. Since 1956, Bonn has been teaching at the Graduate School of Library Service at Rutgers University.

H. RICHARD BLACKWELL has been appointed director of the Institute for Research in Vision at Ohio State University, effective 1 October. He has also been named research professor in the university's department of ophthalmology and School of Optometry. Blackwell leaves the University of Michigan, where he has conducted a vision research program since 1945.

HENRY E. MELENEY, emeritus professor of preventive medicine, New York University, and research professor of medicine, Louisiana State University, will retire from his present position on 30 September. He has been appointed assistant health officer of Alachua County, Gainesville, Fla. His special responsibility will be the development of research and personnel training programs. He will also do some teaching at the College of Medicine of the University of Florida.

Scientific visitors to the United States from the United Kindom include the following:

BARBARA H. BILLING, member of the British Medical Research Council's external staff at the department of surgery, Royal Veterinary College, London, will be in this country from mid-September till 20 December. She will spend a month in the department of internal medicine, Cincinnati General Hospital, and 2 months in the department of biochemistry at the Mayo Clinic.

J. E. LOVELOCK, member of the staff of the National Institute for Medical Research, Mill Hill, London, will spend approximately 6 months, commencing 12 October, in the department of internal medicine at Yale University School of Medicine as a member of the Yale University visiting faculty. He will take part in a program of research closely related to his own work, the lipid metabolism of red blood cells.

KATHERINE TANSLEY of the Medical Research Council's Ophthalmological Research Unit, London, will be a visiting scientist at the National Institutes of Health, Bethesda, Md., for a period of 1 year, beginning 4 October.

HENRY S. ODBERT has been named program director for psychobiology, Division of Biological and Medical Sciences, National Science Foundation. He was formerly chief of the occupational analysis branch of the Personnel Laboratory, Detachment No. 1 of the Wright Air Development Center, Lackland Air Force Base, Tex.

E. J. ARIENS, professor of pharmacology and chairman of the department of pharmacology at Nijmegen University, Nijmegen, Netherlands, presented two lectures in mid-September at the department of pharmaceutical chemistry, School of Pharmacy, University of Maryland, Baltimore.

ARTHUR H. MOREY of Erie, Pa., manager of the Railroad Locomotive Advance Engineering Unit of the General Electric Company, will receive the George R. Henderson Medal from the Franklin Institute on 15 October for his work in connection with developing the gas turbine-electric locomotive.

Recent Deaths

ERIC DE BISSCHOP, Auckland, New Zealand; 66; French oceanographer and explorer; died during a trip by raft in the South Seas through which he hoped to prove that Polynesian peoples could have drifted from the South Seas to South America and back again; 30 Aug.

GEORGE H. CLOWES, Indianapolis, Ind.; 80; biochemist who helped to develop the first commercial production of insulin in this country; pioneer in the study of spontaneous recovery from cancer in animals; research director of Eli Lilly and Company from 1929 until his retirement in 1946; was for 18 years with the New York State Institute for the Study of Malignant Diseases in Buffalo before joining Eli Lilly and Company; 26 Aug.

LOUIS J. CURTMAN, White Plains, N.Y.; 70; head of the qualitative analysis division of the department of chemistry at City College in New York until his retirement in 1944; member of the research staff of Harriman Research Laboratory at Roosevelt Hospital in New York from 1913 to 1921; author of many books and textbooks; 30 Aug.

RALPH K. DAY, Columbus, Ohio, 61; research forester at the Central States Forest Experiment Station for more than 30 years; 23 Aug.

EDWIN S. GAULT, Philadelphia, Pa.; professor of pathology at the Temple University Medical School; 1 Sept.

MARSHALL O. LEIGHTON, Cape Elizabeth, Me.; 84; consulting engineer in Washington, D.C., for many years; former chief hydrographer for the Federal Government; did hydroelectric power explorations in Mexico and in the Andes Mountains in 1929; 29 Aug.

RAYMOND P. LUTZ, Princeton, N.J.; 57; director of research at the new Western Electric Research Laboratory in Hopewell; 30 Aug.

ALLISTER M. MACMILLAN, Ithaca, N.Y.; 49; senior research associate in the department of sociology and anthropology at Cornell University since 1950, and associate professor of sociology in the department of psychiatry at the university's Medical College since 1957; made major contributions in the early development of social psychiatry; was developing a screening survey for use in the study of mental illness in the community at the time of his death; 13 Aug.

ANDREW L. NELSON, Union, N.J.; 54; formerly oceanographer with the Lamont Geological Observatory, Palisades, N.Y., and commander of the British research ship *Discovery II,* which made three trips to Antarctica; 26 Aug.

A. JUDSON QUIMBY, New York, N.Y.; 83; physician and one of the first clinical professors of radiology; consultant on radiology and roentgenology at Polyclinic Hospital before retirement in 1950; director of the department of radiology and roentgenology at the hospital's postgraduate medical school; 1924–36; devised an x-ray gall bladder test and a kidney x-ray; founder of the American College of Radiology; 24 Aug.

HARRY J. SNOOK, Stockton, Calif.; 72; biologist and former teacher at Stockton College; co-author of *Seashore Animals of the Pacific Coast;* 22 Aug.

JESSIE STEWARD, Boston, Mass.; 44; assistant director of the Massachusetts General Hospital School of Nursing; supervisor and teacher at the Massachusetts Eye and Ear Infirmary for 6 years before joining the school of nursing; 28 Aug.

FORD L. WILKINSON, Terre Haute, Ind.; 63; president of Rose Polytechnic Institute since 1949; academic dean of the United States Naval Academy Post Graduate School before 1949; 1 Sept.

Book Reviews

Physics and Philosophy. The revolution in modern science. Werner Heisenberg. Introduction by F. S. C. Northrop. Vol. 19 of *World Perspectives*, Ruth Nanda Anshen, Ed. Harper, New York, 1958. xv + 206 pp. $4.

This is in many ways a fascinating and stimulating work. In the main, Heisenberg's remarks comprise a presentation of his view of the historical roots of atomic science, of the current status of quantum theory and the extent to which it constitutes a radical break with antecedent physical theories, and of the "consequences" of quantum theory on society as well as on science. The book is so organized that each of its 11 chapters, while emphasizing one or the other of these topics, nevertheless manages to provide material relevant to all three. The contents were originally given as the Gifford lectures at the University of St. Andrews and are wholly nontechnical—at least nonmathematically-technical—in character. Of particular interest to physicists is likely to be Heisenberg's treatment of quantum "revisionists," and also his view of the future prospects of physical theory. In the chapter on "Criticism and counterproposals to the Copenhagen interpretation," he briefly considers, among others, such views as those of Bohm, Fenyes, Weizel, Einstein, Schrodinger, and the Soviet scientists Blochinzen and Alexandrov; on varying grounds he finds all of these relatively inadequate.

With respect to the future prospects of physical theory, Heisenberg first gives a nontechnical account of what he takes to be the incompatibility of quantum theory with the theory of special relativity. The pressing desideratum for theoretical physics is a viable unifying theory. The kind of candidate theories which seem most to intrigue him on this score are those which involve "the phenomenon of time reversal" (pages 162–65). He believes that "there must exist a third universal constant in nature. This is obvious for purely dimensional reasons. . . . One needs at least three fundamental units for a complete set. . . . A unit of length, one of time, and one of mass is sufficient to form a complete set. . . . One could also replace them . . . by units of length, velocity and energy. . . . Now, the velocity of light and Planck's constant of action provide only two of these units. There must be a third one, and only a theory which contains this third unit can possibly determine the masses and other properties of the elementary particles. Judging from our present knowledge of these particles the most appropriate way of introducing the third universal constant would be by the assumption of a universal length the value of which should be roughly 10^{-13} cm, that is, somewhat smaller than the radii of the light atomic nuclei" (pages 164–65). Just as certain anomalies (vis-à-vis the "common-sense" view of the world) have been associated with the introduction of the two accepted constants, so too Heisenberg seems to expect similar apparent anomalies to be associated with the *length-constant*. In particular, "we should be prepared for phenomena of a qualitatively new character when we in our experiments approach regions in space and time smaller than the nuclear radii. The phenomenon of time reversal, which has been discussed and which so far has only resulted from theoretical considerations as a mathematical possibility, might therefore belong to these smallest regions" (page 165). The sense of "time reversal" involved is the following: the theory would predict such phenomena as the creation of particles at some point in space but would also predict that the energy of *this* phenomenon would *later* be "provided for by some other collision process between elementary particles at some other point" (page 163).

On the whole, when Heisenberg is describing actual developments in modern physics, or even when he is engaged in what we might call speculative *physics* (as illustrated in the preceding paragraph), his account is rewarding—at least to a nonphysicist it seems lucid and perspicuous. In somewhat painful contrast, however, is his speculative metaphysics. In the first place his historical review of the philosophical antecedents of present-day physical theory, though compromising roughly one-fifth of the work, is routine, quite superficial (especially his treatment of Hume—one sentence, page 84), and contains some astonishing solecisms: he attributes to Berkeley the exact converse of Berkeley's view (page 84), he makes no mention whatever of Leibnitz, and he apparently credits Weizsäcker with the meta-language–object-language distinction and the notion of multivalued logics (pages 182 ff.).

More grave, however, than the deficiencies of his historical account is the dubiousness of his interpretations of the metaphysical "implications" of quantum. These considerations indeed constitute the bulk of the work, but I shall deal only very briefly with two of the many questions that they raise.

Heisenberg believes that the indispensable occurrence of the concept "probability" in the Copenhagen interpretation (to which he subscribes) of quantum theory entails, in at least one respect, something very much like an Aristotelian metaphysic. The fact that the concept is, unlike statistical concepts in other physical theories, not even theoretically eliminable in quantum signifies for him that it is "a quantitative version of the old concept of 'potentia' in Aristotelian philosophy" (page 41). The ineliminable use of the concept, he feels, has "introduced" an entirely new (for physics) dimension of reality—"something standing between the idea of an event and the actual event, a strange kind of physical reality just in the middle between possibility and reality" (page 41). But this is a gratuitous conclusion, the acceptance of which is certainly rendered implausible by many of the things which Heisenberg himself has to say in the very next chapter (Chapter III). Indeed, since the concepts "reality," "possibility," "subjectivity," "*midwayness* between possibility and reality," and so forth do not occur in quantum theory at all, it is clear that any conclusions which are drawn involving them are deducible not from that *theory* but only from some metaphysical presupposition about that theory or about "reality."

For the independent establishment of such presuppositions, *Physics and Philosophy* adduces no scintilla of evidence. The book does not establish that quantum has any metaphysical implications at all. What it does show is that familiarity with quantum can *cause* even brilliant men to articulate and espouse metaphysics. In fact it is just the confusion between the logical and the causal consequences of quantum which pervades and vitiates a good deal of what Heisenberg has to say about the social, linguistic, religious, and scientific "consequences" of the theory.

These ungracious remarks, however, will have failed in their intention should anyone be influenced by them not to read the book. I think that it is a book

which every scientist, every person interested in the history of ideas, will find profitable and enjoyable. It is exciting, even—indeed especially—in those passages which do not entirely persuade.

RICHARD RUDNER
Department of Philosphy, Michigan State University

Bone and Radiostrontium. Arne Engstrom, Rolf Björnerstedt, Carl-Johan Clemedson, and Arne Nelsen. Wiley, New York; Almquist and Wiksell, Stockholm, Sweden, 1957. 139 pp. Illus. $8.75.

For lack of a consistent editorial viewpoint this book is a puzzling mixture of general introductory material and highly specialized reports of research. It is aimed at no particular group or level. For all of that, the "shotgun approach" is not entirely without merit. Pieces and sections of the book will be interesting to almost anyone. For example, the casual scientific reader will find the introductory chapter a fine, annotated bibliography of the Sr^{90} fallout literature. The rest of the book he can and will ignore; it's much too specialized. The bone specialist will find the introduction boring, but later he will encounter a good summary of the important work on microstructure of bone for which the Karolinska group has earned an enviable reputation. To the radiation biologist, the discussions of bone microstructure are a bit "thick," but the calculations of radiation dosage will be new and exciting.

I came upon two minor annoyances. In the specialized sections, the referencing is chauvinistic. There are only rare references to work done outside the Karolinska "family," and this is a field which has been built by many men of many nations. The other annoyance is with the final summary. Here, the authors wrestle weakly with the problem of Maximal Permissible Concentrations. It would have been better either to give the problem "full treatment" or not to mention it at all.

WILLIAM F. NEUMAN
Atomic Energy Project, School of Medicine and Dentistry, University of Rochester

The Mushroom Hunter's Field Guide. Alexander H. Smith. University of Michigan Press, Ann Arbor, 1958. ii + 197 pp. $4.95.

A simple yet authoritative field manual for the identification of mushrooms has long been needed in this country, since most of the books available to the amateur mushroom collector are either obsolete in their nomenclature or limited in their geographical coverage. The preparation of a manual for the nonspecialist has been made difficult by recent progress in the taxonomy of higher fungi, because much of this progress has resulted from the use of microscopic characters for the identification of species, so that identification of some mushrooms in the field has become impossible even for the specialist. Fortunately, some of the species that are of particular importance to those interested in mushrooms as food can be recognized in the field on a basis of macroscopic characteristics and habitat.

Alexander H. Smith, curator of fungi in the Herbarium of the University of Michigan, has selected some 124 species of fungi that can be recognized in the field for inclusion in *The Mushroom Hunter's Field Guide.* In addition to mushrooms (Agaricales), the book includes other Basidiomycetes such as coral fungi, shelf fungi, chanterelles, and puffballs and edible Ascomycetes such as the morels and their relatives. For each species listed, there is at least one photograph, together with paragraphs on (i) when and where to find the species, (ii) the important characteristics for field identification, and (iii) a discussion of its edibility. Poisonous species are clearly indicated, but Smith advises caution in eating others, because some individuals are sensitive to mushrooms that most people find innocuous.

In addition to the main part of the book, there is an introduction, written in nontechnical language, which tells a little about the place of mushrooms in the scheme of things, the structure of mushrooms, and the variability of their characteristics. It also contains some general remarks about eating mushrooms and mushroom poisoning. There are also useful lists of the names of species found in the western United States, of edible mushrooms safe for beginners, of mushrooms associated with certain trees, and of the habitats of selected mushrooms according to season.

The book has two unusual external features. The first is its shape. It is shaped to fit the pocket—that is, if one happens to have pockets of 5¼ by 10¾ inches. A second and laudable feature in a book designed for field use is the water-repellent cover.

The two most important requisites for a useful field manual are workable keys and adequate illustrations. One disadvantage to artificial keys of the type found in this book is the fact that the user does not know whether he is "getting warm" or not, so that if he makes a mistake, he is lost. He is also lost if the key is misleading. For example, if *Helvella gigas* were found in the Sierra Nevada, it could not be identified by means of the key, because the choice leading to this species requires that it must occur in the Rocky Mountains.

Any deficiencies in the keys are more than compensated for by the illustrations, which are truly excellent—large, clear, and well-reproduced. Smith is an outstanding photographer, and many of his illustrations have esthetic qualities as well as scientific utility.

The Mushroom Hunter's Field Guide should have a wide appeal and help to fill the need for a book of its kind. Although it is written for the beginner, it should be useful to the more advanced collector because of its authoritativeness and the extent of its geographical range. Finally, it should be helpful as a reference work for physicians, but it is to be hoped that this attractive and scientifically accurate book will help to forestall unnecessary illness and needless deaths from mushroom poisoning.

ROBERT M. PAGE
Department of Biological Sciences, Stanford University

Young People's Book of Science. Glenn O. Blough, Ed. McGraw-Hill, New York, 1958. 446 pp. Illus. $4.50.

Space Book for Young People. Homer E. Newell, Jr. McGraw-Hill, New York, 1958. 114 pp. Illus. $2.95.

Frontiers of Science. Lynn Poole. McGraw-Hill, New York, 1958. 173 pp. Illus. $3.25.

These three books are intended primarily for children from grades four through nine. However, the general public would benefit from their use. This is especially true of *Frontiers of Science* by Lynn Poole.

Young People's Book of Science is a collection of selections from the writings of the Bendicks, Crouse, Grant, Hyde, Kimble, Poole, Richardson, Schnieder, Schwartz, Skilling, Stillman, Sullivan, Swezey, and Tannenbaum, ranging in nature from those of historical significance to others concerned with modern science.

Many methods of gathering evidence are discussed, from using your eyes, without optical instruments, up to and including use of the electron microscope. Also included are studies of weather, atomic energy, space travel, the ocean, and electricity, including television. Although all the topics are presented in a factual, yet stimulating, manner, the portion devoted to the ocean is most fascinating. This includes descriptions of the geology of the ocean floor as well as of marine biology. As you read this section, you can actually visualize a dive using a scuba or snorkel.

Space Book for Young People includes a very readable presentation of elemen-

tary astronomy (covering the planets, the sun, the moon, comets, asteroids, meteors, stars, and galaxies) and the structure of rockets to be launched into space. The simple approach to a quantitative concept of the vastness of the universe is of particular note. The entire book is simple, yet informative.

Frontiers of Science is truly a book about modern scientific development. The description of the use of the evaporograph as a means of taking pictures in the dark and the study of geobotany will be of interest to the scientifically minded person. The individual who is interested only in the sociological aspects of science will appreciate the chapters devoted to the theories of invention and diffusion in the discussion of human geography, the use of drugs in treating mental illness, and the treatment of organic diseases. In chapter 16 there is an excellent elementary discussion on the glow of the firefly.

It is difficult to describe these three books adequately in a short review. They present truth as it exists and should stimulate young people to study science. They all help to show the reader that the curtain of ignorance is being pushed ever farther open.

MILTON O. PELLA
School of Education,
University of Wisconsin

American Agriculture: Geography, Resources, and Conservation. Edward Higbee. Wiley, New York; Chapman & Hall, London, 1958. x + 339 pp. Illus. $7.95.

This is a general book on the geography of American agriculture. Following three introductory chapters on broad land resources, climate, and soil, the author discusses the present agricultural patterns in the western states (13 chapters) and in the eastern states (11 chapters). The selected regions are discussed mainly in terms of the dominant physical features and present trends of land use. Maps and charts are used freely to illustrate the major regions. Diagrams of about 35 selected farms and several of communities, forest areas, and subregions are used to illustrate typical situations. Most of these are excellent but some of the large and complex ones of broad regions have been reduced too much.

In the regional chapters the author uses his case farms and such discussions as he feels will be helpful—sometimes he emphasizes soils, sometimes climate, and so on, depending on the area. Frequently he refers to significant historical, economic, and technological factors, and the effects of the agricultural programs for price supports, soil conservation, and the like. Since he does not do this consistently throughout, the basis for his selection of factors for discussion is not clear.

Orderly economic analyses of his sample farms would have helped the reader get a clear idea of the operating budgets of these farms.

Apparently the book is intended as a text for geography students who have had little or no previous training in agricultural science. It will help these students to get a conception of the variability and complexity of American agriculture and some general notion of the potentialities of our rural lands and of the problems of their use.

CHARLES E. KELLOGG
U.S. Soil Conservation Service,
Washington, D.C.

Oil: From Prospect to Pipeline. Robert R. Wheeler and Maurine Whited. Gulf Publishing Company, Houston, 1958. ix + 115 pp. Illus. $2.95.

This very concise account of oil operations is intended for laymen and oil company personnel. Such a book has long been needed by the rather departmentalized professional and clerical staff of the oil companies and by countless mineral owners and investors in the oil business. It should be of great value to students contemplating a career in petroleum geology and other fields of oil technology.

In a clear and often entertaining fashion the authors have covered the technical, economic, legislative, and competitive aspects of finding and producing oil, using nontechnical language easily understood by laymen. A description of the first six chapters of the book follows:

"Oil is how you find it" considers the environment of oil accumulation and the techniques of evaluating prospects and exploring for production, all of which are within the province of the petroleum geologist.

"Drilling for oil" discusses the roles of the geologist and engineer in supervising drilling and testing operations.

"Getting the oil to market" discusses reservoir mechanics and the problems of securing oil production from the well bore.

"Who owns the oil" is a fascinating excursion into the legal problems of ownership, conservation, and legislation designed to promote the equitable sharing of this valuable natural resource.

"What's it worth" is an analysis of supply and demand, cost and profit, and unique tax legislation designed to encourage oil exploration—in general, a study of the economics of the domestic oil business.

"Pride, participate or promote" is an often amusing effort to compare the major and independent oil companies with regard to their philosophies of conducting oil operations, which run the gamut from pure prejudice to the most refined technology.

Following the main text of the book is chapter 7, an abridged oil dictionary designed to aid the secretarial-clerical staffs of the oil companies and conveying a good deal of the colorful language of the "oil patch."

The dictionary is followed by abbreviations used in oil reports, a tabulation of regional stratigraphic terminology for the important oil-producing regions in the United States, typical legal forms of mineral conveyance, and other useful tables concerning taxable income and fractional production equivalents.

Even to the experienced oil operator, this book will be of considerable interest and value because, as noted earlier, there is very little overlap between the professional departments in the oil companies. While it will not make experts of the geologists, geophysicists, reservoir engineers, landmen, and accountants in fields other than their own, it will give them some insight into and appreciation of the jobs of others.

Although most of the chapters could have been treated in considerably more detail, it was quite evidently the authors' object to treat each subject as concisely and consistently as possible. The simplicity and clarity of statement that characterize this presentation undoubtedly derive from the facts that Wheeler and his secretary, Maurine Whited, manage the operations of the Pyramid Oil & Gas Corp., and that the idea of the book was to help simplify each phase of oil operations for their directors and co-investors.

R. M. SWESNIK
General American Oil Company of
Texas, Dallas

The Chemical Industry during the Nineteenth Century. A study of the economic aspects of applied chemistry in Europe and North America. L. F. Haber. Clarendon Press, Oxford, England, 1958 (order from Oxford University Press, New York). viii + 292 pp. $7.20.

This book defines its object as the filling of a gap in economic history, a gap that encompasses the chemical industry during its period of greatest growth. Without exhausting the subject, Haber accomplishes remarkably well the organization of this complex and obscure subject into a coherent and readable narrative. He proceeds through the jungle of sprouting and decaying business structures of the late 19th-century chemical industry with a facility which has

not, to my knowledge, been demonstrated heretofore. To a considerable extent he owes this facility to his unusual familiarity with both British and German sources. To this he adds an ability to correlate the scientific and the technical with the economic. This will come as no surprise to those who recognize him as the son of Fritz Haber, whose name is associated with ammonia synthesis.

The sulfuric acid, soda ash, caustic soda, bleaching powder, and coal-tar dye industries are described in detail—an obvious core around which revolved other chemical industries which are only briefly touched upon here. Of particular interest is the account of the struggle for survival of the Leblanc soda industry. Although the author refrains from emphasizing the point unduly, scientists will be interested to note the scientific weakness of the great British soda combine which, in its declining days, employed 50 chemists in 45 works—a ratio of 1 to each 240 employees.

The account of the German dye industry comprises the most penetrating and original part of the book, at least from the point of view of the English reader, and is especially useful in view of our tendency to regard the growth of this industry as something of a devious plot. Since the book ends with the 19th century, it leaves much of this story untold. The account of American development is competently handled, but serves as a reminder that the 19th century was not a period of great chemical enterprise in this country.

The book is well documented and indexed and is attractively printed.

ROBERT P. MULTHAUF
Department of Science and Technology, Smithsonian Institution

New Books

Computability & Unsolvability. Martin Davis. McGraw-Hill, New York, 1958. 235 pp. $7.50.

Correlation between Physical Constants and Chemical Structure. Graphical statistical methods of identification of mineral and fatty oils, glass, silicones, and catalysts. H. I. Waterman in collaboration with C. Boelhouwer and J. Cornelissen. Elsevier, Amsterdam, 1958 (order from Van Nostrand, Princeton, N.J.). 127 pp. $5.25.

The Eternal Search. The story of man and his drugs. Richard R. Mathison. Putnam's, New York, 1958. 381 pp. $5.95.

Electric Conduction in Semiconductors and Metals. W. Ehrenberg. Oxford Univ. Press, New York, 1958. 399 pp. $10.10.

Handbuch der Physik. vol. VI, *Elasticity and Plasticity.* S. Flügge, Ed. Springer, Berlin, 1958. 649 pp. DM. 145.

Die Infektionskrankheiten des Menschen und ihre Erreger. vols. 1 and 2. A. Grumbach and W. Kikuth. Thieme, Stuttgart, Germany, 1958. 1742 pp. $47.15.

International Review of Cytology. vol. VII. G. H. Bourne and J. F. Danielli, Eds. Academic Press, New York, 1958. 692 pp. $16.

Introductory Horticulture. E. P. Christopher. McGraw-Hill, New York, 1958. 490 pp. $7.50.

Medical Terminology Simplified. Louis L. Perkel. Thomas, Springfield, Ill., 1958. 115 pp. $3.85.

Modern Chemical Processes. A series of articles describing chemical manufacturing plants. vol. 5. Editors of *Industrial and Engineering Chemistry* in conjunction with the technical staffs of the cooperating organizations. Reinhold, New York; Chapman & Hall, London, 1958. 154 pp. $5.

Nuclear Scattering. K. B. Mather and P. Swan. Cambridge Univ. Press, New York, 1958. 477 pp. $14.50.

The Physiology and Pathology of the Cerebellum. Robert Stone Down and Giuseppe Moruzzi. Univ. of Minnesota Press, Minneapolis, 1958. 682 pp. $12.50.

Science Students' Guide to the German Language. A. F. Cunningham. Oxford Univ. Press, London, 1958. 199 pp. $2.

The Principles of Biological Control. Interrelation of hosts and pests and utilization in regulation of animal and plant populations. Harvey L. Sweetman. Brown, Dubuque, Iowa, 1958. 572 pp. $8.75.

Proceedings of the Congress on Modern Analytical Chemistry in Industry. Held at the University of St. Andrews, 24–28 June 1957. Organised by the Scottish Section of the Society for Analytical Chemistry. Heffer, Cambridge, England, 1958. 231 pp.

The Properties of Gases and Liquids. Their estimation and correlation. Robert C. Reid and Thomas K. Sherwood. McGraw-Hill, New York, 1958. 398 pp. $10.

Readings in Medical Care. Edited by the Committee on Medical Care Teaching of the Association of Teachers of Preventive Medicine. Univ. of North Carolina Press, Chapel Hill, 1958. 729 pp. $6.50.

Roaming Britain. 8000 miles through England, Scotland and Wales. Willard Price. Day, New York, 1958. 318 pp. $5.75.

Solid State Physics. Advances in research and application. vol. 6. Frederick Seitz and David Turnbull, Eds. Academic Press, New York, 1958. 443 pp. $12.

Sound Pulses. F. G. Friedlander. Cambridge Univ. Press, New York, 1958. 213 pp. $7.50.

Subsurface Geology in Petroleum Exploration. A symposium. John D. Haun and L. W. LeRoy, Eds. Colorado School of Mines, Golden, 1958. 893 pp. $10.

The Tarantula. William J. Baerg. University of Kansas Press, Lawrence, 1958. 97 pp. $3.

A Treasury of Science. Harlow Shapley, Samuel Rapport, Helen Wright, Eds. Harper, New York, ed. 4, 1958. 789 pp. $6.95.

Voice across the Sea. Arthur C. Clarke. Harper, New York, 1958. 221 pp. $3.75.

Electric Machinery. A coordinated presentation of A-C and D-C machines. Clifford C. Carr. Wiley, New York; Chapman & Hall, London, 1958. 547 pp. $9.25.

The World's Nations. An economic and regional geography. George F. Deasy, Phyllis R. Griess, E. Willard Miller, Earl C. Case. Lippincott, Philadelphia, Pa., 1958. 991 pp. $10.

Handbuch der Physik. vol. VII, *Crystal Physics II,* 273 pp., DM. 60.80; vol. XXVI, *Light and Matter II,* 972 pp., DM. 134.40. S. Flügge, Ed. Springer, Berlin, 1958.

Miscellaneous Publications

(Inquiries concerning these publications should be addressed, not to Science, but to the publisher or agency sponsoring the publication.)

Cost Estimation Methods in Unemployment Insurance, 1909–1957. Harry Malisoff. New York State Department of Labor, Bureau of Research and Statistics, New York 18, 1958. 167 pp.

Serial Publications of the Soviet Union, 1939–1957. A bibliographic checklist. Compiled by Rudolf Smits. Cyrillic Bibliographic Project, Library of Congress, Washington, 1958 (order from Supt. of Documents, GPO, Washington). 459 pp. $2.75.

Educators Guide to Free Films. Compiled and edited by Mary Foley Horkheimer and John W. Diffor. Educators Progress Service, Randolph, Wis., ed. 18, 1958. 616 pp. $7.

Human Blood in New York City. A study of its procurement, distribution and utilization. Conducted by the Committee on Public Health, New York Academy of Medicine. H. D. Kruse, General Director of Study. New York Acad. of Medicine, New York, 1958. 147 pp.

The Training Program of the National Institute of Mental Health, 1947–1957. U.S. Department of Health, Education, and Welfare, Public Health Service, Washington, 1958. 65 pp.

Sanitary Engineering Education in Peru. A report of the School of Public Health of the University of North Carolina, Chapel Hill. A project for technical assistance to the National University of Engineering of Peru. Sponsored by the International Cooperation Administration–Institute of Inter-American Affairs, September 1954–May 1958. Univ. of North Carolina, Chapel Hill, 1958 (order from Dr. Daniel A. Okun, Department of Sanitary Engineering, Univ. of North Carolina, Chapel Hill). 51 pp. Free.

Some East African Pleistocene Suidae. Fossil Mammals of Africa, No. 14. L. S. B. Leakey. British Museum (Natural History), London, 1958. 133 pp. 4d 10s.

Joint FAO/WHO Expert Committee on Brucellosis. Third report. WHO Tech. Rept. Ser., No. 148. World Health Organization, Geneva, 1958 (order from Columbia University Press, New York 27). 51 pp. $0.60.

Automation and Remote Control (Soviet journal *Avtomatika i Telemekhanika* in English translation). Instruments Society of America, 313 Sixth Ave., Pittsburgh 22, Pa. General subscription, $30; libraries of academic and other non-profit institutions, in U.S. and Canada, $15; 12 issues per year.

Reports

Nature of Meromyosins

Following up the observation of Gergely (*1*) that a partial digestion of myosin with trypsin leaves its adenosine triphosphatase activity intact, Mihalyi (*2*) and Szent-Gyorgyi (*3*) isolated two large fragments of myosin from the digested mixture. The heavier of the two components carrying the adenosine triphosphatase activity was named H-meromyosin (H), the lighter component L-meromyosin (L) (*3*). Since these components are liberated in about equal weights and since H is about twice as heavy as L (L's molecular weight, 100,000) the myosin molecule must contain one H and two L components.

Since the meromyosins in their amino acid composition add up to myosin (*4*), they can be considered as the primary products of splitting, essentially unmodified by further digestion. In addition to trypsin other proteolytic enzymes such as chymotrypsin (*5*), subtilisin (*6*), and snake venom (*7*) have been found to split myosin, yielding products roughly similar to those produced by trypsin. Since these enzymes split ester bonds as well as peptide bonds, it is important to study the C-terminal groups of the split products to see whether those groups which appear correspond to the known specificity requirements of these enzymes.

Although the L-meromyosins produced by these enzymes appear very similar, they exhibit subtle differences. Gergely (*8*) found that L-meromyosin obtained with the digestion of chymotrypsin yielded 1 mole of phenylalanine as a C-terminal end group when studied with carboxypeptidase A (*8*). With the discovery of a new carboxypeptidase (*9*), specific for basic amino acids, it was possible to demonstrate the presence of a C-terminal lysine on the L-meromyosin produced by trypsin (*10*).

The appearance of these C-terminal groups is in agreement with the known specificity requirements of these proteolytic enzymes. The L-meromyosin produced by snake venom again is different since it has a C-terminal alanine (*7*). From these observations one must conclude that the meromyosins are the proteolytic split products of myosin and as such should not be considered as pre-existing subunits of myosin. Nevertheless, since tracer studies show that the two fragments of myosin have different turnover rates (*11*), at least two subunits of some kind pre-existing in the muscle can be postulated.

For the arrangement of the meromyosins in the myosin molecule, Holtzer and Rice (*12*), from light-scattering evidence, proposed the arrangement LLH. In the interpretation of light-scattering data summation of shape considerations presents a difficult problem which can be solved only with simplifying assumptions.

The fact that both L- and H-meromyosin have "wounded" ends (*13*) supports the LHL arrangement. There are other chemical and biochemical facts that support this arrangement; here I want to point out one which appears quite decisive against the LLH arrangement.

The arrangement LHL is symmetrical and permits a molecular weight of the myosin monomer to be about 220,000, one-half of the current value of about 440,000.

The recent careful experiments of Ellenbogen and co-workers (*14*) show that the molecular weight of myosin from dog heart is about 223,000. Since myosin of twice this size, obviously a dimer, also has been obtained from heart muscle, an arrangement of the meromyosins in myosin (MW = ~ 440,000) must be such as to permit the halving of the molecule.

Evidence is mounting to show that myosin is more complex than the meromyosins would imply. Kominz in this laboratory isolated from myosin without the use of proteolytic enzymes a protein (about 12 percent myosin) rich in phenylalanine and very much different from the meromyosins (*15*). Alcohol denaturation was found to split L-meromyosin into a crystalline and noncrystalline component (*16*), showing the complexity of L-meromyosin.

To unravel the detailed composition of myosin is very important because it is becoming more and more apparent that without such knowledge the role of myosin in muscular contraction will not be understood.

K. LAKI

National Institute of Arthritis and Metabolic Diseases, National Institutes of Health, Bethesda, Maryland

References

1. J. Gergely, *J. Biol Chem.* **200**, 543 (1953).
2. E. Mihalyi, *ibid.* **201**, 197 (1953); ——— and A. G. Szent-Györgyi, *ibid.* **201**, 189 (1953).
3. A. G. Szent-Györgyi, *Arch. Biochem. Biophys.* **42**, 305 (1953).
4. D. R. Kominz, A. Hough, P. Symonds, K. Laki, *ibid.* **50**, 148 (1954).
5. J. Gergely, M. A. Gouvea, D. Karibian, *J. Biol. Chem.* **212**, 165 (1955).
6. W. R. Middlebrook, *Abstr. 1958 Meeting Biophys. Soc.* (1958), p. 46.
7. D. R. Kominz, personal communication.
8. J. Gergely, H. Kohler, W. Ritschard, L. Varga, *Abstr. 1958 Meeting Biophys. Soc.* (1958), p. 46.
9. J. E. Folk, J. A. Gladner, K. Laki, *Federation Proc.* **16**, 181 (1957).
10. J. A. Gladner and J. E. Folk, *J. Biol. Chem.* **231**, 393 (1958).
11. S. F. Velick, *Biochim. et Biophys. Acta* **20**, 228 (1956).
12. A. Holtzer and S. A. Rice, *J. Am. Chem. Soc.* **79**, 4847 (1957).
13. K. Laki, *J. Cellular Comp. Physiol.* **49**, Suppl. 1, 249 (1957).
14. E. Ellenbogen, R. Iyengar, H. Stern, R. G. Olson, in preparation; personal communication.
15. D. R. Kominz, *Federation Proc.* **17**, 256 (1958).
16. C. Cohen and A. G. Szent-Györgyi, *J. Am. Chem. Soc.* **79**, 248 (1957).

24 April 1958

Soluble Deoxyribosidic Compounds in Relation to Duplication of Deoxyribonucleic Acid

One of the puzzling features of chromosome reproduction is the abruptness and relative rapidity with which the chromosomal substance is synthesized. Wherever the phenomenon has been adequately studied, whether in cells of plant, animal, or microorganism, the duplication of deoxyribonucleic acid (DNA) has consistently been found to occur during a comparatively brief interval in the life span of the cell. This behavior is in marked contrast to that of many other cell components which fluctuate in concentration or increase gradually in amount during cellular development.

The cause and course of DNA duplication is but little understood. Not even in phage-infected bacteria, where the

Instructions for preparing reports. Begin the report with an abstract of from 45 to 55 words. The abstract should *not* repeat phrases employed in the title. It should work with the title to give the reader a summary of the results presented in the report proper. (Since this requirement has only recently gone into effect, not all reports that are now being published as yet observe it.)

Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to Contributors" [*Science* **125**, 16 (1957)].

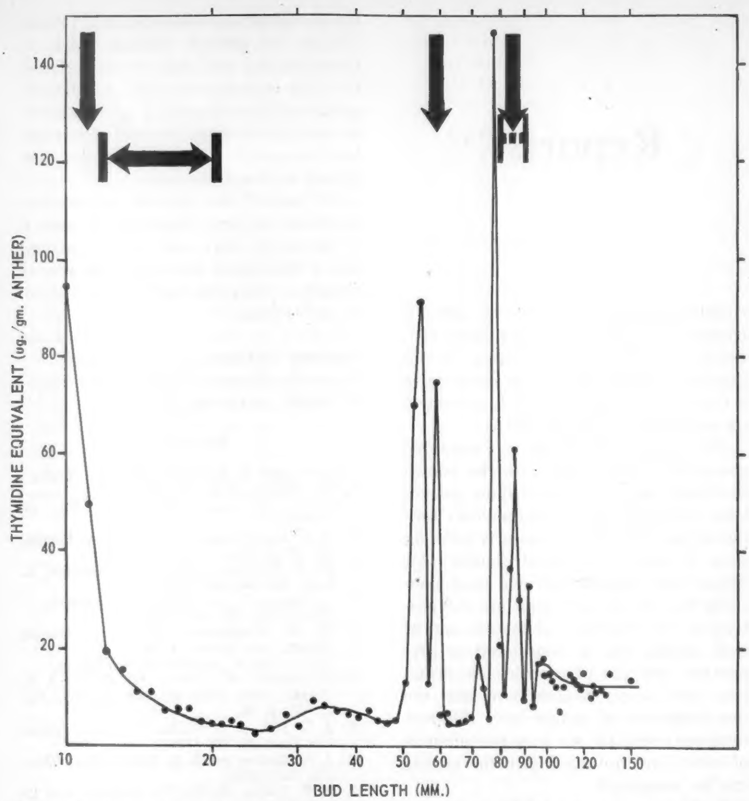


Fig. 1. Variations in soluble deoxyribosidic compounds with anther development. Methanolic and trichloroacetic acid extracts were incubated at *p*H 9.0 with a commercial preparation of alkaline phosphatase for 20 hours at 37°C. *Lactobacillus acidophilus* R-26 was the test organism. Vertical arrows indicate periods of DNA synthesis with sporogenous tissue as established by Ogur *et al.* (*4*) and by Taylor and McMaster (*5*). Microsporocyte meiosis and microspore mitosis were checked cytologically. The third period of DNA synthesis is marked with a bar because of the uncertainty covering its precise occurrence. Tapetal DNA synthesis is indicated by a horizontal arrow.

immediate stimulus to DNA synthesis is known and controllable, is the chain of events entirely apparent. It could be assumed that the whole complex of synthetic pathways from deoxyribose production to deoxyribonucleotide polymerization is tightly integrated and activated as a unit, whether by a viral or an intracellular agent. But the fact, so clearly demonstrated by Schneider (*1*), that pyrimidine deoxyribosides occur in blood and in various nonproliferating organs of mammals suggests a slightly looser association between precursor formation and ultimate polymerization. It is conceivable that one of the mechanisms by which a cell limits chromosome reproduction is by controlling the availability of soluble deoxyribosidic compounds.

This report (*2*) on the occurrence of deoxyribosidic substances in anthers of *Lilium longiflorum* var. Croft bears on the latter point. The suitability of anthers for the study of mitotic processes has previously been discussed (*3*). It need only be indicated here that during the interval of development studied there are three periods of DNA synthesis (*4, 5*). The first precedes microsporocyte meiosis and tapetal cell mitosis; the second precedes microspore mitosis; and the third occurs during pollen maturation. In the brief account of experiments which follows it is shown that immediately prior to each instance of DNA synthesis there is a marked accumulation of soluble deoxyribosidic compounds.

Buds of appropriate length which had been stored at −30°C were extracted first with 0.05*M* methanolic formic acid and then with 5 percent trichloroacetic acid. Each of these extracts was analyzed for deoxyribosidic material before and after treatment with mucosal phosphatase. The microbiological assay technique of Hoff-Jørgensen as modified by Schneider (*1, 6*) was employed. To guard against the possibility that growth-promoting factors other than deoxyribosidic ones were present in the extracts, parallel assays with added thymidine were run for each developmental stage. No synergistic effects were observed. Both methanolic and trichloroacetic extracts, whether or not they were treated with phosphatase, shared a common pattern with respect to location of peak concentrations of the deoxyribosidic compounds. The extracts differed qualitatively (*7*). The quantitative features of the pattern are illustrated in Fig. 1, in which the deoxyribosidic contents of the phosphatase-treated extracts were summed and the values so obtained were plotted against length of the bud.

There are three outstanding peaks in concentration of deoxyribosidic compounds during anther development, and each of them is associated with an interval of DNA synthesis. The first of these precedes microsporocyte meiosis and tapetal mitosis; for technical reasons buds of lengths less than 10 mm were not collected, and hence a phase of ascending concentration has to be assumed. The second peak precedes microspore mitosis, and the third coincides with the beginning of the interval of DNA synthesis in the maturing pollen.

Two properties of each of the peaks are distinctive: (i) the level of concentration is some 25 times that of the base one, and (ii) the duration of the high levels is of the same order as that of DNA synthesis. It may be inferred from these results, as Schneider has already done for animal tissue (*1, 8*), that DNA is formed from soluble deoxyribosidic compounds. It may also be inferred that the chain of events leading to DNA duplication begins with an abrupt activation of enzymes metabolizing these soluble deoxyribosidic compounds. Whether the accumulation of such compounds is of itself sufficient to initiate polymerization, or whether the two processes are separately activated, remains to be learned from enzymatic studies (*9*).

T. S. Foster
Herbert Stern
Chemistry Division, Science Service, Canada Department of Agriculture, Ottawa, Ontario

References and Notes

1. W. C. Schneider, *J. Biol. Chem.* 216, 287 (1955).
2. This article is contribution No. 392, Chemistry Division, Science Service, Canada Department of Agriculture.
3. H. Stern, *Science* 124, 1292 (1956); R. O. Erickson, *Nature* 159, 275 (1947).
4. M. Ogur, R. O. Erickson, G. U. Rosen, K. B. Sax, C. Holden, *Exptl. Cell Research* 2, 73 (1951); J. H. Taylor and R. D. McMaster, *Chromosoma* 6, 489 (1954).
6. We express our thanks to Dr. W. C. Schneider, National Cancer Institute, Bethesda, Md., for helpful consultation, and to our Bacteriology Division for assistance with the microbiological assay.
7. A fuller account of these differences is in preparation.
8. W. C. Schneider and L. W. Brownell, *J. Natl. Cancer Inst.* 18, 579 (1957).
9. Some of these data were discussed at the 41st annual conference, Chemical Institute of Canada, Toronto, 26–28 May 1958.

31 March 1958

Effects of Amygdaloid Lesions upon Septal Hyperemotionality in the Rat

A striking increase in emotional behavior, manifested by violent attack or flight reactions in response to previously neutral stimuli, has been reported to result from experimental damage to the septal region of the forebrain in the laboratory rat (*1, 2*). A behavioral shift in the opposite direction occurs following lesions of the amygdaloid nuclei. Karli (*3*) and Woods (*4*) report that damage of this complex in the aggressive and unmanageable wild rat results in tameness and greatly lowered emotional reactivity.

The present investigation (*5*) was designed to obtain further information concerning the relative roles of the septal and amygdaloid regions of the brain in affective behavior by combining, in the same animal, lesions which produce opposite behavioral extremes. Thirty male hooded rats of the Lashley strain were used in this study, and the behavior of each animal was evaluated daily on a rating scale of emotionality. The scale was adapted, with certain modifications, from one used by Brady and Nauta (*1*) and contained the following six components: (i) attack or flight reaction to a rod presented visually before the rat's snout, (ii) startle reaction to a light tactual stimulation, (iii) resistance to capture, (iv) muscular tension and resistance to handling, (v) vocalization during testing, (vi) urination and defecation during testing. Each of these components was evaluated on a scale from 0 through 5, and an over-all daily score was assigned each animal by adding up the scores obtained for each component of behavior. All brain lesions were bilateral and were produced electrolytically with a unipolar electrode inserted by means of a stereotaxic instrument.

In experiment 1 the effects of amygdaloid damage imposed upon an already hyperemotional septal animal were evaluated. Ten animals designated septal-amygdaloid and five rats designated septal-cortical were rated on the emotionality scale for 3 days preoperatively; then both groups were subjected to septal damage and rated for 3 days following the operation. The next day all 15 animals were reoperated; ten were subjected to amygdaloid damage, and the remaining five received cingulate and neocortical lesions as a control for the effects of brain damage per se. From Fig. 1 it is clear that following septal damage all animals showed a striking increase in emotionality over preoperative values ($p < .01$). Further, the effect of an amygdaloid lesion imposed upon a septal preparation is to reduce suddenly the hyperemotionality observed during the 3 days following the septal operation ($p < .01$). In fact, such animals appear to return approximately to their preoperative emotional levels. Those septal animals which received cingulate and neocortical damage in lieu of amygdaloid lesions showed the gradual decline in emotional reactivity reported in previous studies in which only the septal area had been destroyed (*1, 2*).

Since amygdaloid lesions were found to produce a profound reduction in the emotionality of septal preparations, experiment 2 was performed to determine whether amygdaloid lesions placed prior to septal damage would effectively prevent the appearance of septal hyperemotionality. In this experiment ten animals designated amygdaloid-septal and five rats designated cortical-septal were rated on the emotionality scale for 3 days preoperatively. The former group was then subjected to amygdaloid damage, and the latter group received cortical lesions. Following three more days of ratings, all animals were reoperated and subjected to septal damage. Figure 2 shows that neither the initial amygdaloid nor cortical damage had an effect upon emotionality. When septal damage was then imposed upon the control group of five cortical-septal animals, an increase in emotionality similar in all observable respects to that seen in animals receiving septal damage alone was manifested. In the case of the experimental group of amygdaloid-septal animals, amygdaloid lesions were successful in preventing the appearance of a full-blown septal hyperemotionality. However, these animals did show a gradual, but only partial, development of hyperemotionality, differing from both their own preoperative values and the values reached by the septal-cortical group in experiment 1 at the .05 level of confidence.

The brain of every animal was studied histologically. In general, damage was restricted to the structures for which the lesion was intended, and no other structures of the brain consistently suffered injury. All animals designated "septal" were found to have suffered severe destruction of the precommissural and supracommissural portions of the septal region. Those animals designated "amygdaloid" all sustained damage to the amygdaloid complex; most heavily and consistently damaged were the lateral and basal nuclei. In no case was there total destruction of the amygdala. The animals referred to as "cortical" controls were found to have lesions of the anterior cingulate and adjacent neocortex.

It may be noted that, in contrast to previous studies (*3, 4*), amygdaloid lesions alone did not reduce affectivity. We suspect that the rats used in the present experiment were so low in emotionality preoperatively that differentiation by the rating scale in the direction of lowered emotionality was not possible.

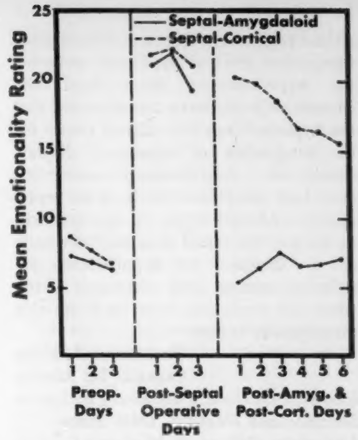


Fig. 1. Daily mean ratings of emotionality for septal-amygdaloid and septal-cortical operates.

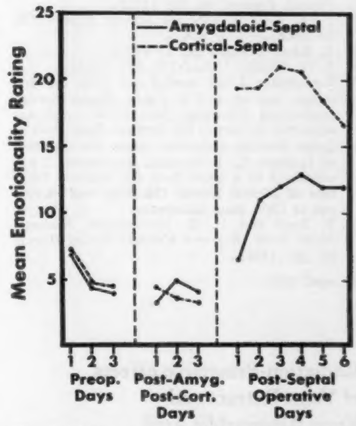


Fig. 2. Daily mean ratings of emotionality for amygdaloid-septal and cortical-septal operates.

Studies now in progress in this laboratory, in which rats with an initially high level of emotional responsivity are being used, indicate that this was probably the case, for such animals show a decided and sudden drop in reactivity following amygdaloid lesions. It is curious that amygdaloid lesions were able to produce total reduction of septal hyperemotionality in experiment 1, but only partial suppression in experiment 2; and although we are presently unable to offer a satisfactory explanation, it is conceivable that the effects of the amygdaloid lesions in experiment 2 have become partially dissipated by the time the septal lesion is placed, thus permitting a degree of hyperemotionality to appear.

The results of this study suggest that the septal region and amygdaloid nuclei may play reciprocal roles in the control of affective behavior. It appears possible that impulses from the septal and amyg-

daloid regions are directed toward some integrative level of the brain, probably the hypothalamus, since Bard and Mountcastle (*6*) have demonstrated that the hypothalamus is a critical center for the integration of emotional display. Furthermore, hypothalamic connections have been established for both the septal and amygdaloid areas. It appears that, in the rat, the septal area may normally act to "dampen" the hypothalamic activity associated with emotional states, while the amygdala may facilitate this diencephalic center.

FREDERICK A. KING
PATRICIA M. MEYER
Research Division, Columbus Psychiatric Institute and Hospital, Ohio State University College of Medicine, Columbus

References and Notes

1. J. V. Brady, W. J. H. Nauta, *J. Comp. and Physiol. Psychol.* **46**, 399 (1953).
2. F. A. King, *J. Nervous Mental Disease* **126**, 57 (1958).
3. P. Karli, *Behavior* **10**, 81 (1956).
4. J. W. Woods, *Nature* **178**, 869 (1956).
5. Experiment 1 was carried out while the first author was on a U.S. Public Health Service predoctoral fellowship (MF-5490-C), and was submitted as part of his doctoral dissertation at Johns Hopkins University, under the direction of Professor C. T. Morgan. Experiment 2 was supported by a grant from the National Institute of Mental Health (M-1639) and carried out at Ohio State University.
6. P. Bard and V. B. Mountcastle, *Research Publs. Assoc. Research Nervous Mental Disease* **27**, 362 (1947).

24 April 1958

Radiation-Protective Effects of Yeast Extract and Yeast Ribonucleic Acid

Most of the work with biological substances in the field of radiation protection has been with proteins, amino acids, animal cells, and their extracts. Studies involving the administration of embryonic cells, viable spleen and bone marrow cells, either in the pre- or postirradiation period, have been voluminous and unequivocally show varying degrees of protection.

On the other hand, experience with plant substances and yeasts in particular has been quite limited. It has been demonstrated by Jaraslow *et al.* (*1*) that the administration of an autolysed yeast extract to rabbits is capable of protecting the postirradiation response to certain immunologic stimuli. Hollaender and Doudney (*2*) have demonstrated that irradiated *Escherichia coli* grown aerobically in nutrient broth recover from x-ray effects to a considerable degree if they are plated after irradiation on agar containing yeast extract. In studies designed to evaluate the role of properdin in radiation protection, Ross *et al.* (*3*) studied postirradiation survival of rats and mice after injections of zymosan. A moderate protective effect was demonstrated. Because of the suggestion from these studies that yeast and yeast extracts might have radiation-protective properties, an evaluation study in rodents was performed.

Autolysed yeast extract was prepared according to the method described by Jaraslow *et al.* (*1*) in which dried brewer's yeast was incubated with isotonic phosphate buffer at *p*H 7.4 at 37°C for 12 hours and then centrifuged at 20,000 *g* for 30 minutes. The clear supernatant autolysate was used for injection. For each experiment fresh yeast autolysate was prepared. Within from 15 to 30 minutes prior to irradiation, 200-g Sprague-Dawley rats were injected either intravenously or intraperitoneally with 1.0 ml of the autolysate.

In the first experiment, a total of 27 injected rats were compared with a group of 50 uninjected controls. In the second experiment, 15 eleven-week-old C_3H mice were injected either intraperitoneally or intravenously with 0.5 ml of the yeast autolysate. The survival rate of these mice was compared with that of 105 uninjected controls. Thirty minutes after injection the rats were placed in a polyethylene box and irradiated in pairs so that each animal received a total body dose of 900 r of x-ray over a period of 17 minutes. In a similar fashion the mice were placed in a plastic container and given 700 r of total-body radiation of x-ray over a period of 20 minutes. The number of surviving animals then was checked at daily intervals during the 30-day postirradiation period. All but one of the uninjected control rats were dead by the 13th postirradiation day, and this animal succumbed on the 21st day. On the other hand, 11 of the 27 injected rats (41 percent) were alive on the 30th day after irradiation. Four of the 15 yeast autolysate-injected mice (27 percent) were alive on the 30th day after irradiation, whereas all of the uninjected

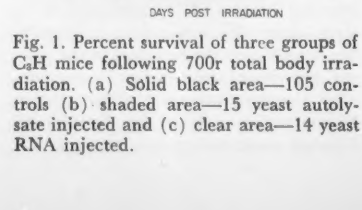


Fig. 1. Percent survival of three groups of C_3H mice following 700r total body irradiation. (a) Solid black area—105 controls (b) shaded area—15 yeast autolysate injected and (c) clear area—14 yeast RNA injected.

control mice were dead by the 14th postirradiation day. In both groups of animals the results obtained with intravenous and intraperitoneal injections were comparable. It also was noted that even the nonsurviving rats and mice lived longer than did the irradiated controls.

The results of these experiments indicated that the crude yeast autolysate provided a moderate degree of radiation protection to lethally irradiated animals. Yeast autolysate is extremely rich in ribonucleic acid (RNA), and there is good evidence that RNA is essential for protein synthesis. Studies with transplanted, irradiated nuclei of amoebae (*4*) suggest that irradiated cytoplasmic constituents of these cells are deleterious to normal nuclear function. Daniels (*5*) has suggested that non-nucleated cellular components of normal amoebae are capable of restoring nuclear function to irradiation-damaged cells. The high RNA content of cellular cytoplasm of many protective tissue extracts made it seem possible that the RNA of the yeast autolysate was its most important protective constituent and prompted investigation of the radiation-protective effects of this nucleic acid.

A group of 14 eleven-week-old, C_3H mice were injected intraperitoneally with either 10 or 20 mg of a commercial preparation of yeast RNA containing less than 1 percent protein (Schwarz Laboratories). The RNA concentration of the solution used for injection was 2.0 g/100 ml. Fifteen to 30 minutes later these animals were exposed to 700 r of total-body irradiation. Nine of the 14 injected mice (64 percent) were alive at the end of 30 days. These results are to be compared with no survival in the control group of 105 mice, and with 27 percent survival in the group injected with crude yeast autolysate (Fig. 1). There is some indication from these data that the dose of RNA may be of importance since only one of the five mice that died received the 20-mg dose.

In each of the three cases, a chi-square test was applied to determine whether the difference in survival rates between the two groups is significant. The resulting *P*-values are less than 0.001 in all three. These results indicate that the preirradiation injection of a crude yeast autolysate exerts a moderate radiation-protective effect in rats and mice. Postirradiation survival is considerably enhanced with a commercial yeast-RNA preparation. It is of interest that a plant extract devoid of viable cells and rich in RNA is capable of exerting protective effects to a degree comparable to that of many mammalian cells and tissue extracts. Preliminary results indicate that RNA, or a substance associated with it in the yeast autolysate, may be the principal radiation protective factor (*6*).

Note added in proof: Subsequent to the completion of this study a published article on the protective effects of yeast extracts on irradiated organisms has been located in the Russian literature (*7*).

KATHERINE D. DETRE
STUART C. FINCH
Department of Internal Medicine, Yale University School of Medicine, New Haven, Connecticut

References and Notes

1. B. N. Jaraslow and W. T. Taliaferro, *J. Infectious Diseases* **98**, 75 (1956).
2. A. Hollaender and C. O. Doudeny, *Radiobiol. Symposium Proc. Liège 1954* (1955), p. 112.
3. O. A. Ross *et al.*, *Federation Proc.* **14**, 418 (1955).
4. M. J. Ord and J. F. Danielli, *Quart. J. Microscop. Sci.* **97**, 29 (1956).
5. E. W. Daniels, *Radiation Research* **5**, 604 (1955).
6. We are deeply indebted to Mrs. Mary Perfetto and Mrs. Margaret Butler for their technical assistance, and to Dr. J. W. Hollingsworth for the liberal use of his laboratory facilities. Appreciation also is extended to Dr. W. Vishniac, Dr. Chu H. Chang, Dr. William Prusoff, and Dr. Vincent Allfrey for their assistance and helpful comments.
7. N. V. Lutschnik, *Biochemistry, (Leningrad)* **23**, 146 (1958).

22 April 1958

Audiogenic Abnormality Spectra, Twenty-four Hour Periodicity, and Lighting

Under standardized conditions, certain stocks of mice show 24-hour periodicity in incidence of audiogenic convulsions and in mortality from them (*1*). Thus the proportion of mice with convulsions will differ significantly between comparable groups exposed to identical auditory stimulation at the times of daily high or low in eosinophil count (*1*). At either time of stimulation and in several stocks, the sequence of abnormal events following exposure to noise consists of dashing ("uncontrolled" running) "clonic" convulsion, "tonic" convulsion, and death, in this order, but this sequence is not necessarily started or completed in each animal. In response to noise, a given mouse may only crouch, or walk, or at best run, with relative "control" of its movements (*1, 2*). Herein we raised the questions whether dashing, an early audiogenic abnormality, also may be 24-hour periodic and whether the entire spectrum of periodic audiogenic abnormality can be influenced by the schedule of light and dark. If, as in the case of physiologic rhythms, the timing of abnormal responses to noise can be set by manipulation of lighting, a potentially useful model for the experimental pathologist will be more reliably defined (*3*).

D_8 mice, of both sexes, were weaned at 21 ± 2 days of age and immediately singly housed, with Purina Dog Chow and tap water available *ad libitum*. The cages were kept in rooms maintained at 24 ± 0.5°C and illuminated by artificial light only. One group of mice was in light from 06:00 to 18:00, another in light from 18:00 to 06:00, alternating with 12 hours of darkness in each case. Individual mice from these two groups were transferred from their cages to a stimulator (*4*), within less than 30 seconds. Each stimulation was of 60-second duration, one subgroup from each group being exposed to noise between 20:00 and 22:00, the other between 07:00 and 09:00.

Figure 1 shows "within-day" differences for the entire spectrum of abnormal responses to noise, which stand out clearly irrespective of the lighting regimen used. χ^2-tests were carried out on each difference in the proportion of mice exhibiting a given response at 08:00 and at 21:00, respectively, these differences being analyzed separately for mice on the two lighting schedules. Without exception, the *P* values were smaller than 0.05.

Figure 1 further reveals that mice in light from 18:00 to 06:00, as compared with those in light from 06:00 to 18:00, have shifted the time of day associated with a higher proportion of abnormal responses. This shift in timing of peak abnormality applies to dashing, to the two types of convulsion studied, as well as to the end-point death. Quite clearly, the lighting regimen on which the mice are kept determines the temporal placement within the 24-hour period of all of the abnormal rhythms studied herein, as long as other things remain comparable. Conceivably, the standardization of genetic background, past history, and age has substantially contributed to the significance of the results. The difference in over-all incidence of abnormality, irrespective of time, between the groups on the two regimens of lighting, however, cannot be accounted for with the data on hand. A possible increase in over-all susceptibility to convulsion immediately following a phase-shift of rhythm deserves study.

An earlier suggestion, that lighting is ordinarily the dominant synchronizer of various physiologic rhythms in the mouse (*5*), can now be extended to several physiopathologic periodicities in the same species. It seems noteworthy that (as yet ill-defined) changes underlying abnormal responses to acoustic sensory inflow in mice are among multitudinous 24-hour periodic changes governed in their timing by optic stimulation.

Finally, the present results on the experimental animal have an approximate clinical counterpart. For well over a century, epileptologists have discussed the unequal "within-day" distribution of seizures in some of their patients (for references, see *6*) and convulsive periodicity was studied in the clinic as a potential clue to seizure mechanisms (*6*). Yet progress in the field may have been hindered by the lack of suitable experimental animal models. From this point of view, periodicity analysis on D_8 mice, about 5 weeks of age, yielding the data of this report, may constitute a tool of the experimental pathologist. Most

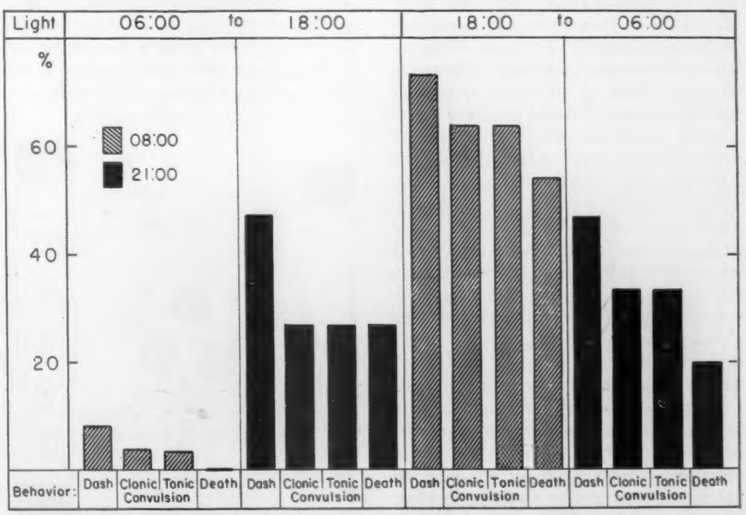


Fig. 1. Abnormal audiogenic responses in D_8 mice, on two schedules of light and darkness, alternating at 12-hour intervals. Note the difference in incidence of abnormality at 08:00 and at 21:00, on each lighting regimen. Note also the difference in time of high abnormality, in mice exposed to light from 18:00 to 06:00, as compared with that in mice exposed to light from 06:00 to 18:00. Total tested: 102 mice, about 5 weeks of age, of both sexes.

likely, nocturnally active D_8 mice with an evening high in audiogenic abnormality may be counterposed to certain types of "morning-fitters" among diurnally active human beings.

Franz Halberg, Elwood, Jacobsen,
George Wadsworth, John J. Bittner
Department of Pathology, Division of Cancer Biology, Medical School, University of Minnesota, Minneapolis, and *Cambridge State School and Hospital, Cambridge, Minnesota*

References and Notes

1. F. Halberg, J. J. Bittner, R. J. Gully, P. Albrecht, L. E. Brackney, *Proc. Soc. Exptl. Biol. Med.* 88, 169 (1955); F. Halberg, J. J. Bittner, R. J. Gully, *Federation Proc.* 14, 67 (1955).
2. L. R. Dice, *J. Mammal.* 16, 25 (1935); J. J. Antonitis, *Science* 120, 139 (1954).
3. This investigation was aided by the Elsa U. Pardee Foundation and by research grants from the U.S. Public Health Service, the Minnesota Department of Public Welfare, and the American Cancer Society.
4. The stimulator was constructed by K. Shimada with advice from H. E. Hartig and R. P. Featherstone. The stimulus yielded by a noise generator was about 117 db (above 0.0002 dy/cm² r.m.s. pressure).
5. F. Halberg, M. B. Visscher, J. J. Bittner, *Am. J. Physiol.* 179, 229 (1954).
6. F. Halberg, *J.-Lancet* 73, 20 (1953); ——, R. J. Gully, R. Engel, M. R. Ziegler, in *Essays on Pediatrics*, R. A. Good and E. S. Platou, Eds. (J.-Lancet, Minneapolis, Minn., 1955), p. 130.

14 April 1958

Agar Substrates for Study of Microepidemiology and Physiology in Cells in vitro

Despite the general usefulness of monolayer cell and tissue cultures on glass, there are experimental situations in which multilayered systems are desirable. Certain shortcomings in monolayer cellular systems for the study of infectious disease are apparent, particularly if a succession of cells must be parasitized to obtain full development of infection or to demonstrate the resistance of cells. The relatively great expanse of cells and fluid nutriments permits exposure of sensitive agents to inhibitory components in the liquid phase. There is loss of viral and bacterial agents and of infected cells during renewal of the supernates (*1*). In the case of microorganisms which can proliferate independently, streptomycin (*2*) or other extracellular inhibitors must be added to ensure an intracellular type of infection.

Combinations of infectious agents with cells or cell colonies on agar provide a contiguity of cells which is closer than that in animal tissues; extracellular inhibitors are of less concern; neither the agent nor the cells can escape the experimental arena. Many microepidemiological problems, therefore, may be studied more advantageously than in the whole animal or in monolayer cell cultures.

The human tubercle bacillus, strain H-37Rv, grows in cell colonies of Earle's L strain of mouse fibrocytes and Gey's strain HeLa. The failure of *Mycobacterium lepraemurium* to achieve more than the usual 2.5- to 3-fold multiplication (*3*) reveals that the problems of this organism are more complicated than the simple need for continuous existence within host cells.

The reservoirs of nutriment provided in the agar systems to be described have also permitted the maintenance of cell cultures for extended periods with minimal care and have proved useful in the study of organized tissue fragments (see also *4*).

Agar substrates were prepared by combining at 50°C double-strength nutriments with equal volumes of 2 to 4 percent purified agar (*5*) in BSS just prior to the preparation of plates, impregnated filter paper strips (*6*), or agar slants (*7*). Plates and impregnated papers were inoculated with cells or tissue fragments without prior drying, while agar slants to carry circumscribed cell colonies were dehydrated in inverted cotton-stoppered tubes overnight at 37°C. Cell inocula were standardized by transferring 2-mm loops (0.0025 ml) from dense, enumerated suspensions of strain L and strain HeLa. Several assemblies of agar systems which provide a reservoir of renewable, slowly available liquid nutriments are shown in Fig. 1.

The development of large bacterial colonies after 24 to 72 hours on agar indicates that diffusion rates are more than adequate for tissue cells. On slants containing 3 ml of serum, 2 percent, Eagle's supplement, and 0.5 percent Bacto-peptone (*3*) without liquid phase, strain L produced relatively thick colonies within 2 weeks at 34°C. Cells at the margins of such colonies were round and clear. If 0.5 ml of liquid phase (1/7 of the system) was replaced each 2 weeks, very thick mucoid colonies developed within 2 months. In such media supplemented with pyruvate (50 mg/100 ml) and citrate (0.03 percent) the maintenance of uniformly high viability after 3 months was shown by exclusion of eosin (*8*) and by vigorous growths following transfers to new media.

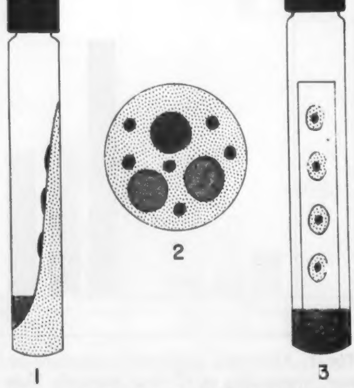


Fig. 1. Agar systems with diffusible nutriments: 1, agar slant; 2, agar plate with three "wells"; 3, agar-impregnated filter paper carrying four cell colonies.

Approximately 5000 L cells were required per site for reliable inoculation of the medium mentioned above. Although incubation in oxygen tensions of 1 to 4 percent, or in the presence of 20 percent serum, decreased the required inoculum, uniform growth was not obtained from less than 2000 cells. Growth of strain HeLa has been initiated with as few as two cells.

Quantitative samples are recoverable from plates or slants by the application of 0.25 percent pancreatin to each cell colony, and by several rinses with known volumes of diluent. Cells are recovered quantitatively from single colonies on plates, slants, or impregnated papers by first removing a disc of agar which includes the colony, and then by use of the foregoing procedure. A bacteriological wire transfers sufficient cells for quantitative determinations of cell types and ratios, the proportion of cells infected, the percentage of cells capable of excluding eosin, and for transfers of viable inoculum.

Fragments of guinea pig bone marrow were explanted on agar slants, plates, and impregnated papers containing 10 percent guinea pig serum and the aforementioned supplements. After 24 hours the migrating cells produced 5- to 10-mm halos in which neutrophils preponderated. The cells within the explants retained typical morphology and staining characteristics for 2 to 3 days. Following the death or modification of various cell types, or both, and after 4 weeks, some 20 to 30 percent of the cells in explants plus deteriorating halos were viable (*9*).

Continuous ciliary beating was observed on the surface of fragments of embryonic chick and embryonic and adult human bronchial tissues during at least two weeks on agar substrates containing 25 percent chicken or human serum and the supplements mentioned (*9*).

It seems, therefore, that cell colonies and tissue fragments on agar substrates are useful for the study of many problems in infectious disease and cellular physiology or differentiation, and also for the maintenance of cell lines with minimal effort (*10*).

John H. Wallace
John H. Hanks
Leonard Wood Memorial, Department of Bacteriology and Immunology, Harvard Medical School, Boston, Massachusetts

References and Notes

1. J. H. Hanks, *Am. Rev. Tuberc. Pulmonary Diseases*, 77, 789 (1958).
2. G. Barski, *Ann. inst. Pasteur* 74, 1 (1948); E. Suter, *J. Exptl. Med.* 96, 137 (1952).
3. J. H. Wallace, S. D. Elek, J. H. Hanks, *Proc. Soc. Exptl. Biol. Med.* 97, 101 (1958).
4. E. T. Wolff and K. Haffen, *Texas Repts. Biol. and Med.* 10, 463 (1952).
5. Difco, especially purified; also Difco Noble Agar.
6. No. 470-A Filter Paper. Carl Schleicher & Schuell Co., Keene, N.H. Made nontoxic by two extractions in boiling distilled water before autoclaving.
7. H. Zinsser, F. Fitzpatrick, H. Wei, *J. Exptl. Med.* 69, 179 (1939).
8. J. H. Hanks and J. H. Wallace, *Proc. Soc. Exptl. Biol. Med.*, 98, 188 (1958).
9. These experiments were conducted in collaboration with Dr. M. Litt and Dr. C. Liu, respectively.
10. The assistance of Miss Jean M. McCarthy is gratefully acknowledged.

28 April 1958

Loss of Precipitating Activity of Antibody without Destruction of Binding Sites

In investigating the composition of the specific combining region of antibody, we have studied the reaction of acetic anhydride with rabbit antibody homologous to the *p*-azobenzoate group. Others have found that acetylation of various antibodies results in loss of ability to precipitate with antigen (*1*). Marrack and Orlans (*2*) reported that when rabbit antibodies against several different antigens were acetylated, they would no longer precipitate, but that a large fraction of each acetylated antibody coprecipitated when added to a mixture of antigen and untreated antibody. They concluded that the failure to precipitate was due either to electrostatic repulsion among protein molecules or to deformation of the antibody molecule resulting from the increased negative charge which accompanies acetylation of amino groups.

In the present work, acetylated preparations of rabbit antibody homologous to the *p*-azobenzoate group were tested for ability to precipitate an ovalbumin-*p*-azobenzoate test antigen, and also to bind homologous hapten [by equilibrium dialysis (*3, 4*)]. Binding experiments provide direct information bearing on the number of combining sites present. It was found that mild acetylation results in complete loss of precipitating activity but that the ability to bind homologous hapten was affected only slightly. The results confirm the hypothesis of Marrack and Orlans and show that an antibody with both combining sites intact may fail to precipitate. Another conclusion is that the nonspecific electrostatic effect in the interaction of this antibody with the negatively charged homologous hapten is small.

Experiments were carried out with antisera obtained from ten rabbits repeatedly injected with a bovine γ-globulin-*p*-azobenzoate antigen, prepared by coupling 30 mg of diazotized *p*-aminobenzoic acid to 1 g of bovine γ-globulin (*4, 5*). The γ-globulin fraction of the pooled antisera was separated by precipitation with sodium sulfate (*6*). Free electrophoresis showed the presence of only one peak, corresponding to γ-globulin. Two 5 ml portions of the globulin (32.4 mg/ml) were acetylated at 0°C by addition, with a microburette, of several portions of acetic anhydride over a period of 15 minutes. The amounts of the reagent used in each experiment are given in Table 1. The mixture was stirred continuously and allowed to react for 1 hour; *p*H was maintained at 8.0 to 8.5 with 0.1*N* NaOH. An untreated control and the acetylated samples were dialyzed overnight against 10 liters of saline-borate buffer at 3° to 5°C and adjusted to the same final protein concentration.

The results are shown in Table 1. The unacetylated globulin and sample A (about 20 percent of the amino groups acetylated) exhibited typical precipitin curves. However, the entire curve for A was displaced downward and, as is indicated in the table, only 41 percent as much precipitate formed at the optimum. No precipitation or turbidity was observed in mixtures of antigen and sample B, which was more extensively acetylated (85 percent of amino groups reacted). In contrast to these results, it is evident (Table 1) that the ability to bind the homologous hapten, *p*-iodobenzoate-I^{131} (*7*) was not greatly affected by acetylation. There was no appreciable difference in the concentration of hapten bound by the control or sample A. In the case of sample B, which formed no precipitate, the concentration of hapten bound, corrected to the same free hapten concentration (*8*), was 79 percent of that bound by the unacetylated sample. This small adverse effect of acetylation on binding may be attributed either to a decrease in the average combining constant (*K*), the loss of effective combining sites, or both. Some decrease in *K* appears likely since the hapten is negatively charged and the net negative charge per molecule in preparation B was increased by about 65 units on acetylation.

We may obtain an estimate of the maximum number of combining sites affected by assuming that *K* was unchanged and that the observed effects on binding were due entirely to the attack of acetic anhydride on groups in the specific combining region of the antibody. It would appear then that a maximum of about one-fifth of the sites or somewhat less than two-fifths of the molecules were affected [assuming random acetylation and the presence of two combining sites per molecule (*9*)]. It is also possible that a smaller number of sites were affected and that a decrease in *K* was partly or entirely responsible for the reduced binding. In any event, the data show that complete loss of precipitability may occur without a corresponding decrease in the number of sites capable of combining with hapten.

The results suggest that the failure of the acetylated antibody to precipitate is attributable to a factor other than attack of the reagent on the specific combining region. It is possible that the acetic anhydride reacts with a group in a part of the combining site which interacts with antigen but lies beyond the region making contact with *p*-iodobenzoate (*10*). However, this alternative cannot apply to the data of Marrack and Orlans (*2*), who used only protein antigens. Their explanation, that acetylated antibody does not precipitate because of electrostatic repulsion resulting from its increased negative charge, can also account for the lack of precipitation in the antiazobenzoate system (*11*). The interaction of

Table 1. Effects of acetylation on the γ-globulin fraction of rabbit anti-*p*-azobenzoate antiserum. Mean deviations given in table are based on duplicate or triplicate analyses. The procedure for acetylation is described in the text.

Sample	Ac_2O used (mg)	No. of amino groups per molecule remaining*	Antibody precipitable by antigen† (μg)	Labeled *p*-iodobenzoate bound‡ ($\times 10^6$M)
Normal globulin	0	–	–	0.21 ± 0.02
Antibody globulin (control)	0	75 ± 8§	228 ± 2	7.5 ± 0.2
Antibody globulin (A)	2.8	58 ± 1.5	93 ± 3	7.2 ± 0.8
Antibody globulin (B)	14	11 ± 1.5	0‖	6.6 ± 0.1

* From van Slyke amino nitrogen analyses. Calculation based on molecular weight 160,000.

† Precipitin reaction with 0.20 ml each of antibody and antigen. The latter was prepared by coupling 60 mg of diazotized *p*-aminobenzoic acid to 1 g of ovalbumin. Values given are for optimum antigen concentration.

‡ Protein concentration, 16.2 mg/ml. Free hapten concentration 1.71 ± 0.06, 1.75 ± 0.07 and 1.90 ± 0.17 × $10^{-6}M$, corresponding to control and samples A and B; and 2.95 ± 0.07 × $10^{-6}M$ for the normal globulin. Values for the antibody preparations are corrected for the small amount of binding by normal globulin.

§ Amino acid analysis (*12*) indicates the presence of 72 free amino groups per molecule.

‖ No turbidity or precipitation observed.

antibody with antigen should be affected more adversely by increased negative charge than that with hapten, since the protein-protein electrostatic repulsion, in the case of the reaction with antigen, is superimposed on that involving the haptenic group. Additional, intermolecular repulsions may also be involved in the formation of aggregates of antibody and antigen.

Finally, it is of interest that the nonspecific electrostatic effect in the interaction of the antibody with hapten is small. With about 65 additional negative charges in the antibody molecule, the binding of *p*-iodobenzoate by antibody was affected only to a small degree (Table 1). In untreated antibody at *p*H 8, the net negative charge per molecule is about 15 or 16 units; thus the nonspecific electrostatic free energy of combination at *p*H 8 is probably negligible. This of course does not preclude the possibility of a very large interaction of opposite charges in the specific combining region.

ALFRED NISONOFF
DAVID PRESSMAN

Department of Biochemistry Research, Roswell Park Memorial Institute, Buffalo, New York

References and Notes

1. B. F. Chow and W. F. Goebel, *J. Exptl. Med.* 62, 179 (1935); G. Sandor and H. Goldie, *Compt. rend. soc. biol.* 126, 295 (1937); ———, *ibid.* 127, 942 (1938); S. J. Singer, *Proc. Natl. Acad. Sci. U.S.* 41, 1041 (1955).
2. J. R. Marrack and E. S. Orlans, *Brit. J. Exptl. Pathol.* 35, 389 (1954).
3. Precipitin reactions were allowed to stand at 3° to 5°C for 5 days. Equilibrium dialysis was carried out at 5° ± 0.1°C. Except as noted, saline-borate buffer, *p*H 8.0, $\mu = 0.16$, was used. Details are given in reference *4*.
4. A. Nisonoff and D. Pressman, *J. Immunol.* 80, 417 (1958).
5. Rabbits were immunized with an antigen made by coupling 30 mg of diazotized *p*-aminobenzoic acid to 1 g of bovine γ-globulin (Armour fraction II). The coupling reaction was carried out at *p*H 9 to 9.5 at 5°C. Details are given in reference *4*.
6. R. A. Kekwick, *Biochem. J.* 34, 1248 (1940).
7. One milliliter of $10^{-6}M$ solution of *p*-iodobenzoate gave approximately 2000 count/min (about 15 times background). Counting efficiency was about 50 percent.
8. The small correction was made by use of the observation, made with a number of different preparations of this antibody (*4*), that the fraction of hapten bound, at hapten concentrations which are small compared to the antibody concentration, does not change appreciably with small changes in the free concentration of hapten.
9. For a given species of site (that is, group of sites having the same K) the concentration of hapten bound is directly proportional to the total concentration of those sites remaining, provided that K and the free hapten concentration are fixed. It follows that the concentration of hapten bound to a heterogeneous population of combining sites, under the same conditions, is proportional to the total concentration of sites. This assumes that acetic anhydride does not react selectively with sites on the basis of their combining constants.
10. Preliminary experiments indicate that the ability of the mildly acetylated antibody to bind the dye, *p*-(*p*-hydroxyphenylazo)-benzoate, is similarly unimpaired. Since this hapten is larger than *p*-iodobenzoate, this result supports the evidence against an attack on the specific combining region.
11. Dr. Schlamowitz of this laboratory, in studies on the phosphatase-rabbit antiphosphatase system, has found that acetylation of the antibody causes a delay in precipitation, but that the antibody still combines with antigen, as evidenced by coprecipitation of the complexes with horse antirabbit γ-globulin antibodies (unpublished results).
12. E. L. Smith, M. L. McFadden, A. Stockell, V. Buettner-Janusch, *J. Biol. Chem.* 214, 197 (1955).

23 January 1958

Fluorescence Activation Spectra of a Diphosphopyridine Nucleotide Dependent Dehydrogenase

In a previous communication from this laboratory (*1*), the shift and augmentation of the fluorescence spectrum of reduced diphosphopyridine nucleotide (DPNH) (*2*) in the presence of beef heart muscle lactic dehydrogenase (LDH) was reported. It was further reported that an additional shift and increase of the fluorescence spectrum occurs when L-lactate is added to the LDH-DPNH complex, presumably to form an LDH-DPNH-L-lactate complex (*3*). For DPNH, when activated by light having a wavelength of 340 mμ, maximum fluorescence emission occurs at 465 to 470 mμ. For LDH-DPNH and LDH-DPNH-L-lactate complexes, maximum emission is observed at 445 to 450 mμ and 430 to 435 mμ, respectively. Similar shifts in the fluorescence spectrum have recently been reported for other dehydrogenase systems (*4*).

Since the initial observation that the alteration of the fluorescence spectrum of DPNH in the presence of horse liver alcohol dehydrogenase is accompanied by a shift to shorter wavelengths of the *absorption* maximum of DPNH (*5*) several attempts have been made to detect a similar alteration of the absorption spectrum of DPNH in the presence of LDH. However, the magnitude of the absorption change is so small that it could be detected only with the very sensitive spectrophotometer employed by Chance and Neilands (*6*).

Since it is well known that only absorbed light can give rise to fluorescence emission, it occurred to us that in the case of LDH and DPNH, only a small fraction of the absorbed light gave rise to the fluorescence spectrum. As a result, rather pronounced changes in the fluorescence spectrum are accompanied by minute changes in the absorption spectrum. In this case, examination of the activation spectrum should reveal those changes in the absorption spectrum which give rise to fluorescence emission (*7*). Figure 1 illustrates activation spectra of DPNH, LDH, LDH-DPNH complex, and LDH-DPNH-L-lactate complex as measured in the Aminco-Bowman recording spectrophotofluorometer (*8*) in 0.2 ionic strength phosphate buffer, *p*H 6.61, at 20°C. For DPNH, LDH-DPNH complex, and LDH-DPNH-L-lactate complex, the fluorescence monochromator was set at the wavelength of maximum emission. For LDH, the fluorescence monochromator was set at 465 mμ, the wavelength of maximum emission of DPNH. The addition of pyruvate to a final concentration of $1.3 \times 10^{-4}M$ to either the LDH-DPNH or LDH-DPNH-L-lactate systems results in a rapid change to the activation spectrum of LDH alone.

It is clear from Fig. 1 that the wavelength of maximum activation of the LDH-DPNH complex is about 5 mμ less than that of DPNH, and that a further shift of 5 mμ is observed when the LDH-DPNH-L-lactate complex is formed. A striking change in the activation spectrum of LDH is seen at 285 mμ when enzyme-coenzyme and enzyme-coenzyme-L-lactate complexes are formed. Ternary complexes are also formed when structural analogs of L-lactate, such as oxalic, tartaric, tartronic, α-hydroxybutyric, malic, and ascorbic acids, are

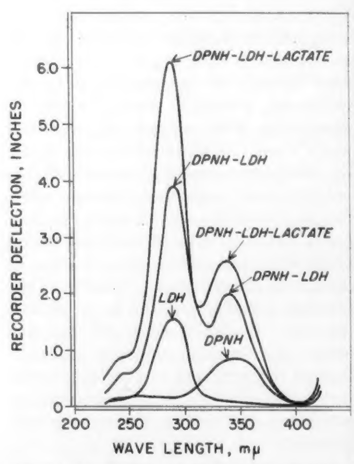


Fig. 1. Fluorescence activation spectra of lactic dehydrogenase and of lactic dehydrogenase complexes with DPNH and with DPNH and L-lactate. The intensity of fluorescence emission at a constant wavelength, as measured by recorder deflection, is plotted against the wavelength of the activating radiation. The curve labeled LDH was obtained with $9.60 \times 10^{-7}M$ LDH. The molecular weight of the enzyme was taken as 135,000 (*10*). The curve labeled DPNH was recorded at a DPNH concentration of $3.94 \times 10^{-6}M$. When DPNH and LDH were each present at the concentration used for the measurement of their separate spectra, the curve LDH-DPNH was obtained. The curve labeled LDH-DPNH-L-lactate was obtained when Na-L-lactate at a final concentration of $1.57 \times 10^{-2}M$ was added to LDH and DPNH present in the concentrations used for the other curves. The background fluorescence of phosphate buffer and L-lactate is negligible at the instrument settings employed.

added to the enzyme-coenzyme complex. The formation of each of these complexes results in changes in the activation spectrum similar to those shown in Fig. 1 for the LDH-DPNH-L-lactate complex (*9*).

With the advent of commercial spectrophotofluorometers by means of which either activation or fluorescence spectra can be recorded, a powerful tool for the investigation of enzyme-coenzyme interactions is available. Since previous attention has been limited to emission spectra, it seemed desirable to call attention to the usefulness of activation spectra for these studies.

A. D. WINER*
G. W. SCHWERT

Department of Biochemistry, Duke University School of Medicine, Durham, North Carolina

References and Notes

1. A. D. Winer, W. B. Novoa, G. W. Schwert, *J. Am. Chem. Soc.* **79**, 6571 (1957).
2. Abbreviations: DPNH, reduced diphosphopyridine nucleotide; LDH, lactic dehydrogenase. The LDH used was the faster migrating electrophoretic component; it was prepared as described by Y. Takenaka and G. W. Schwert, *J. Biol Chem.* **223**, 157 (1956).
3. The formation of the complex LDH-DPNH-L-lactate is specific for the L form of lactic acid; D-lactic acid has no observable effect on either the fluorescence or activation spectra of the LDH-DPNH complex.
4. A. D. Winer and G. W. Schwert, *Biochim. et Biophys. Acta* **29**, 424 (1958).
5. H. Theorell and R. Bonnichsen, *Acta Chem. Scand.* **5**, 1105 (1951); P. D. Boyer and H. Theorell, *ibid.* **10**, 447 (1956).
6. B. Chance and J. B. Neilands, *J. Biol Chem.* **199**, 383 (1952).
7. This investigation was supported by research grant No. RG 2941(C6) from the National Institutes of Health, U.S. Public Health Service.
8. R. L. Bowman, P. A. Caulfield, S. Udenfriend, *Science* **122**, 32 (1955). The instrument was calibrated with a mercury vapor lamp.
9. A paper describing in detail both the detection of these complexes by their fluorescence emission and their properties is in preparation.
10. J. B. Neilands, *J. Biol. Chem.* **199**, 373 (1952).
* Present address: Department of Biochemistry, Nobel Medical Institute, Stockholm, Sweden.

28 April 1958

Root Curvatures Induced by Culture Filtrates of Aspergillus niger

Abstract. Evidence obtained by paper chromatography indicates that corn root curvatures caused by culture filtrates of *Aspergillus niger* are caused by the same compound which causes curvatures and malformations on the stems and petioles of bean plants. The R_f values obtained for this compound were substantially different from those of indoleacetic acid.

I recently reported that when culture filtrates of the fungus, *Aspergillus niger*, are used to treat the growing points of bean seedlings, severe curvatures and malformations are produced on the subsequent growth of the plants (*1*). Malformations consisted of greatly thickened stems and petioles, tumorlike stem protrusions, severely twisted stems, and stems enlarged in only one plane to produce a stem that was wide and relatively flat. Most frequently, curvatures consisted of strong downward bendings of the elongating stem and the compound leaves. In addition, elongation of the first and second internodes above the primary leaves was inhibited. Little or no effect was noted when corn seedlings were treated with the culture filtrate. This report concerns the induction of root curvatures by culture filtrates of *A. niger*.

The methods used for growing the fungus on corn steep–glucose medium and obtaining the culture filtrates were described in the earlier report (*1*). Culture filtrates (*p*H 5) were extracted three times with equal volumes of ether; the ether was removed by evaporation, and the residue was brought up in water and diluted to varying concentrations. Approximately 2.5 ml of the solutions was used to moisten Whatman No. 1 filter paper (9.0 cm) which had been previously autoclaved in petri dishes. Corn seeds (the single cross WF9 × 38-11) were washed thoroughly in deionized water, and six seeds were placed in each petri dish on the periphery of the filter paper. The seeds were arranged in sets of three on opposite "sides" of the dish and oriented so that the roots would grow across the dish toward one another. The seeds were incubated at 27°C and examined at the end of 72 hours.

Figure 1 illustrates the curvature of the roots when the seeds were germinated on the *A. niger* extract (bottom) as compared with seeds placed on water (top) or on an ether extract of the uninoculated culture medium (middle). In a number of cases the roots on the *A. niger* extract formed several complete circles in a tight coil to give the appearance of a corkscrew. Although no quantitative experiments have been performed, it has appeared that the best concentrations for producing root curvatures are between 1/20 and 1/50 of the normal concentration of the culture filtrate. In several experiments, no curvatures were obtained when the seeds were placed on the *A. niger* extract at a concentration equal to that of the unextracted filtrate. At concentrations ranging from 1/20 to 1/50 of that of the unextracted culture filtrate, 50 to 100 percent of the germinated seeds showed strong root curvatures.

It remained to be shown that the compound responsible for the root curvatures was the same as the one causing curvatures and malformations on the stems and petioles of bean plants. Whatman No. 3 paper was cut into strips (4 × 40 cm) and streaked 6.4 cm from the top of the paper with 0.1 ml of 10 × concentration of ether extract of *A. niger* culture filtrate. For purposes of comparison with a naturally occurring growth substance, similar papers were streaked with indoleacetic acid (IAA). A variety of solvents were used to develop the papers, by descending chromatography. When the solvent had moved 25 to 30 cm, the papers were dried and cut into strips 2 cm wide beginning 1 cm above the origin. These strips were eluted with 6 ml of 95 percent ethanol for 2 hours, the papers were removed, and the eluates were evaporated to dryness at 50°C in a forced air oven. The residue was taken up in 1 ml of water which contained four drops of Tween 80 per 100 ml and used to treat the growing points

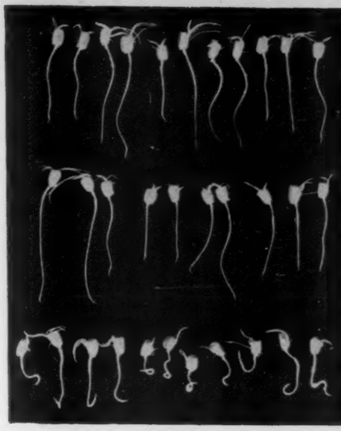


Fig. 1. Roots obtained from corn seeds germinated on filter paper moistened with water (top), ether extract of uninoculated culture medium (middle), and ether extract of *A. niger* culture filtrate (bottom).

Table 1. R_f values of IAA and of the compound produced by *A. niger* causing bean malformations and corn root curvatures, with various solvents.

Compound inducing bean malformations	Compound inducing corn root curvatures	IAA
	Water	
0.85	0.83	0.88
	Ethanol (70%)	
0.95	0.95	0.78
	Phenol (H_2O saturated)	
0.96	0.95	
	Isopropanol:NH_3:H_2O (10:1:1)	
0.93	0.93	0.41
	Pyridine:NH_3 (4:1)	
0.95	0.95	0.53
	Chloroform	
0.00	0.00	0.00
	Chloroform (H_2O saturated)	
0.46	0.46	0.17

of bean seedlings as described earlier (*1*). After treatment of the bean seedlings, the remainder of the eluate was diluted with an additional 9 ml of water and tested for corn root curvatures as described above. If the active compound was found to occur on each of two adjacent strips of the chromatogram, its movement was calculated midway between the two strips. Indoleacetic acid was located on the chromatograms with the ferric chloride–perchloric acid reagent (*2*). The R_f values obtained (Table 1) indicate that the compounds causing root curvatures and bean malformations are identical and have R_f values substantially different from those obtained for IAA (*3*).

ROY W. CURTIS

Department of Botany and Plant Pathology, Purdue University, Lafayette, Indiana

References and Notes

1. R. W. Curtis, *Plant Physiol.* 33, 17 (1958).
2. T. A. Bennet-Clark *et al.*, *Nature* 169, 452 (1952).
3. This report is journal paper No. 1267 of the Purdue Agricultural Experiment Station. I am indebted to Mrs. Nancy Hung and Mrs. Hikmet Egilmez for technical assistance.

28 March 1958

Enzymatic Action of Rabbit Serum on Cortisone Acetate and Hydrocortisone Acetate

Enzymatic activity upon corticosteroids has been reported for tissues (*1*). The only known report, to date, on the enzymatic effect of serum per se is a paper by H. H. Wotiz *et al.* (*2*) on the metabolism of testosterone by human serum. We wish to report (*3*) the presence of an esterase in normal rabbit serum which is absent from normal human serum and which removes the acetate group from cortisone acetate and to a lesser degree from hydrocortisone acetate.

Following the initial studies in this laboratory on the effect of cortisone acetate upon the susceptibility of HeLa cells to poliovirus (*4*), the observation was made that in cultures maintained in Eagle's medium (*5*) with 10 percent human serum the cortisone acetate remained in particulate form, while in those cultures in which rabbit serum was substituted for the human serum the compound soon went into solution.

To investigate this phenomenon quantitatively, three sets of reaction tubes were initiated with 0.9 percent saline (SAL), 10 percent normal human serum in saline (NHS), or 10 percent normal rabbit serum in saline (NRS). To the tubes of each set were added either cortisone acetate (CA) (*6*), hydrocortisone acetate (HCA) (*6*), or hydrocortisone free alcohol (H-OH) (*6*), each resulting in a final concentration of 0.25 mg/ml. All tubes were incubated at 37°C. The hydrocortisone free alcohol was immediately soluble in all three reaction mixtures. The optical density of the tubes containing the steroid acetates was determined immediately and at intervals thereafter. Readings were made on the Bausch and Lomb Spectronic 20 with a wavelength setting of 560 mμ and were corrected with respect to homologous blanks. Figure 1 shows the percentage dissolution of the steroids with time.

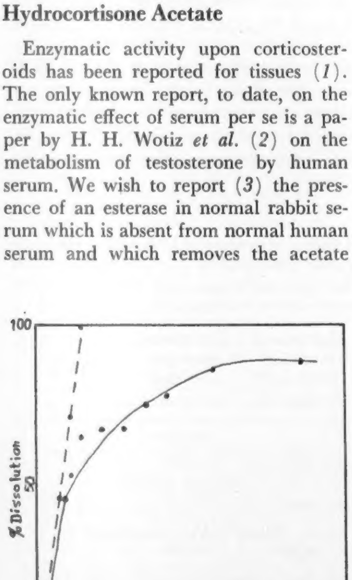


Fig. 1. Percentage dissolution of CA (dashed line) and HCA (solid line) in 10 percent normal rabbit serum in saline (NRS).

Fresh rabbit serum was used in the experiments presented. Considerable activity could still be demonstrated, however, in serum stored at 4°C for 1 month. The heat lability of this enzyme is shown in the experiment summarized in Table 1. Fresh rabbit serum was heated at 56°C for 30 minutes. Comparable tubes were set up with NRS made with heated and unheated serum. Either HCA or CA was added at a final concentration of 0.25 mg/ml. Optical density values were followed with a Coleman, Jr. spectrophotometer with a wavelength setting of 560 mμ.

When a *p*H indicator such as phenol red was incorporated with the reaction mixture, it was seen that a *p*H drop from 7.4 to 6.8 occurred during the reaction period, indicating the formation of an acid. This did not occur in either the 0.9 percent saline or the 10 percent normal human saline reaction mixtures.

Samples of the NRS cortisone acetate reaction mixture were analyzed by the Merck Sharp & Dohme Research Laboratories. Their paper strip data showed that cortisone free alcohol was essentially the only form of cortisone present in the final reaction mixtures (*7*).

We conclude that normal rabbit serum contains an esterase capable of splitting CA into the free alcohol and

Table 1. Optical density readings on Coleman, Jr. spectrophotometer. Normal rabbit serum unheated versus normal rabbit serum heated. All readings were corrected to a saline NRS blank of constant zero reading.

Time (hr)	CA, not heated	CA, heated	HCA, not heated	HCA, heated
0.00	0.32	0.31	0.20	0.20
0.25	0.28	0.31	0.18	0.20
0.50	0.22	0.31	0.17	0.20
0.75	0.12	0.31	0.097	0.20
1.00	0.00	0.31	0.097	0.20
2.00	0.00	0.31	0.097	0.20
3.00	0.00	0.31	0.097	0.20
24.0	0.00	0.31	0.097	0.20

acetic acid. Rabbit serum also has esterase activity toward hydrocortisone acetate. Human serum did not exhibit either esterase activity in the 24-hour test period.

R. B. SHOUGER
M. M. SIGEL

Department of Bacteriology, University of Miami School of Medicine, Coral Gables, Florida

References and Notes

1. D. H. Nelson, L. T. Samuels, D. G. Willardson, F. H. Tyler, *J. Clin. Endocrinol.* 11, 1021 (1951); D. C. West and L. T. Samuels, *J. Biol. Chem.* 190, 827 (1951); M. L. Sweat, L. T. Samuels, R. Lumry, *ibid.* 185, 75 (1950); C. D. West, *Endocrinology* 49, 467 (1951); ———, F. H. Tyler, H. Brown, L. T. Samuels, *J. Clin. Endocrinol.* 11, 897 (1951); H. H. Wotiz and H. M. Lemon, *J. Biol. Chem.* 206, 525 (1954); B. Hurlock and P. Talalay, *Proc. Soc. Exptl. Biol. Med.* 93, 560 (1956); R. I. Dorfman, *Ann. Rev. Biochem.* 26, 523 (1957); D. H. Nelson, *Adrenal Cortex* (Josiah Macy, Jr. Foundation, New York, 1951), pp. 106–114.
2. H. H. Wotiz, R. R. van Baerle, H. M. Lemon, *J. Biol. Chem.* 213, 969 (1955).
3. This work was supported by the National Science Foundation.
4. M. M. Sigel and A. R. Beasley, *Proc. Soc. Exptl. Biol. Med.* 88, 86 (1955).
5. H. Eagle, *Science* 122, 501 (1955).
6. Manufactured by Merck Sharp and Dohme.
7. L. H. Sarett, Merck Sharp and Dohme, personal communication.

16 April 1958

Pericentral Cortical Projections to Motor and Sensory Nuclei

In an experimental neuroanatomical study in the cat (*1*) in which the Nauta-Gygax silver impregnation technique (*2*), was used, some of the corticobulbar fibers were found to be distributed (i) to the spinal trigeminal complex and the adjacent lateral tegmentum up to the level of the isthmus and (ii) to the region of the nuclei cuneatus and gracilis. No corticofugal fibers were distributed to the motor nuclei. Moreover, lesions within the limits of the cat's "motor cortex" (*3*) revealed that the projection to the spinal trigeminal complex and the adja-

cent lateral tegmentum originates primarily in the face area, while the projections to the region of the nuclei cuneatus and gracilis arise primarily in the arm and leg areas, respectively.

In four human cases (*4*) with extensive lesions of the hemisphere, a similar distribution was observed; here, however, degenerating fibers reached the motor nuclei, a projection almost completely lacking in the cat. These differences suggested that in the cat the corticofugal impulses reach the cranial motor nuclei "indirectly" through one or more synapses in the spinal trigeminal complex or the lateral tegmentum, or both. In man, this indirect pathway is paralleled by additional "direct" corticonuclear connections. The existence of "direct" and "indirect" corticonuclear connections is substantiated by electrophysiological findings of a similar nature in regard to the spinal cord, reported by Bernhard and Bohm (*5*).

In an attempt to gain more detailed information concerning the origin of these projections in man, lesions were placed in the precentral face area of the rhesus monkey and the chimpanzee (*6*). These lesions were found to produce degeneration of corticofugal fibers to the motor nuclei and the lateral part of the tegmentum adjacent to the trigeminal complex. The corticonuclear fibers were found to originate primarily in the posterior part of the precentral gyrus, while the projections to the lateral tegmentum exhibited a more diffuse precentral origin. However, in comparing the findings in these animals with those in our human material (*4*) it was interesting to note that in both the rhesus monkey and the chimpanzee, following precentral lesions, only a few degenerating fibers were distributed to the spinal trigeminal complex proper. In the human material, on the other hand, in which the lesions were rather extensive, such degenerating fibers to the trigeminal complex were much more abundant. These differences suggested that the fibers to the lateral tegmentum and the motor nuclei constitute a predominantly precentral projection, while those to the secondary sensory cell groups of the trigeminus constitute a primarily postcentral projection. This was substantiated by the findings in three additional experiments in the rhesus monkey, with lesions of the postcentral face area, in which the degenerating fibers were found to be distributed primarily to the trigeminal complex (*6*).

On the basis of these findings in the brainstem, the inference was made that in the spinal cord a similar arrangement might exist. In order to investigate this further, an extensive series of experiments was initiated in which in the rhesus monkey lesions were placed in the pre- and postcentral cortical regions. Although this extensive study has not yet been completed, the first group of experiments with lesions in the upper two-thirds of the pre- and postcentral gyri revealed an arrangement similar to that in the brainstem. The lesions in the precentral gyrus produced degeneration of corticofugal fibers which were primarily distributed to the intermediate region and the anterior horn of the spinal cord. Lesions in the postcentral gyrus, on the other hand, produced degeneration of corticofugal fibers distributed primarily to the posterior horn of the spinal cord. However, some overlap between the pre- and postcentral projections seems to exist, especially in the leg area.

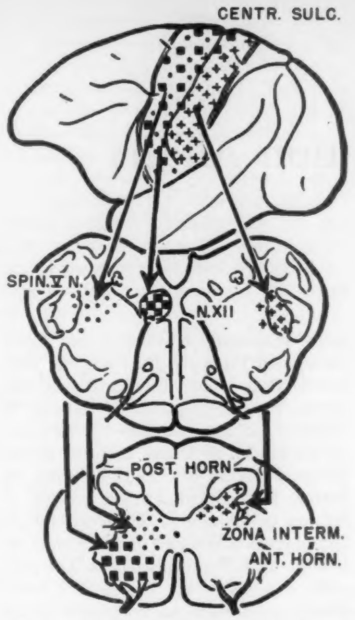


Fig. 1. Diagrammatic representation of the distribution pattern in the corticobulbar and corticospinal projections in the rhesus monkey.

The total of these findings suggest that in the corticobulbar and corticospinal projections (see Fig. 1), at least three main groups can be distinguished: (i) a primarily precentral projection to the internuncial elements (the lateral parts of the tegmentum of the lower brainstem and the external basal parts of the posterior horn and the zona intermedia of the spinal cord); (ii) a primarily precentral projection to the motor neurons (cranial motor nuclei, and spinal anterior horn cells), which seems to be characteristic of primates; (iii) a primarily postcentral projection distributed to secondary sensory cell groups (trigeminal complex and posterior horn of the spinal cord). The first two groups of projections from the precentral "motor" cortex in all likelihood are primarily involved in "motor" functions. The third group of projections, on the other hand, probably constitutes a "sensory" feedback mechanism capable of influencing secondary sensory cell groups, from which the postcentral gyrus ultimately receives at least part of its information. Such a cortical influence upon secondary sensory cell groups in the spinal cord was demonstrated physiologically in the cat by Hagbarth and Kerr (*7*).

Moreover, another cortical projection system was found to be distributed to the region of the nuclei cuneatus and gracilis (*1, 6*). However, in the rhesus monkey the origin of this system does not seem to be limited to the postcentral gyrus but in part arises from the precentral gyrus (*6*). This holds true especially for the projections from the precentral leg area to the region of the nucleus gracilis. This projection system probably represents another sensory feed back mechanism primarily involved in proprioceptive sensory modalities. In this respect it is interesting to note that the differential cortical origin of the projections to the nucleus proprius and the nuclei cuneatus and gracilis, respectively, seems to parallel the possible differences in cortical receiving areas for such sensory modalities (*8*).

Since the pyramidal tract contains the majority of the corticofugal fibers discussed above, the present findings are apt to throw new light upon this classic "motor"system. In fact, they suggest that within the pyramidal tract, at least, two subdivisions can be distinguished, one of which is, in all likelihood, primarily involved in "motor" functions, while the other is primarily involved in "sensory" functions; this concept has already been suggested by Peele (*9, 10*).

H. Kuypers

Department of Anatomy, University of Maryland Medical School, Baltimore

References

1. H. Kuypers, *Anat. Record* **124**, 322 (1956); *J. Anat.* **92**, 193 (1958).
2. W. J. H. Nauta, and P. A. Gygax, *Stain Technol.* **29**, 91 (1954).
3. H. W. Garol, *J. Neuropathol. Exptl. Neurol.* **1**, 139 (1942).
4. H. Kuypers, *Brain*, in press.
5. C. G. Bernhard and E. Bohm, *A.M.A. Arch. Neurol. Psychiat.* **72**, 473 (1954).
6. H. Kuypers, *J. Comp. Neurol.*, in press.
7. K. E. Hagbarth and D. I. B. Kerr, *J. Neurophysiol.* **17**, 295 (1954).
8. W. R. Adey, R. Porter, I. D. Carter, *Brain* **77**, 325 (1954); C. N. Woolsey, W. H. Marshall, P. Bard, *Bull. Johns Hopkins Hosp.* **70**, 399 (1942).
9. T. L. Peele, *J. Comp. Neurol.* **77**, 693 (1942).
10. These investigations were supported in part by research grant No. B-1131 from the division of Neurological Diseases and Blindness of the U.S. Public Health Service.

21 April 1958

Association Affairs

AAAS Washington Meetings, 1854–1958

When the Association of American Geologists and Naturalists was reorganized to become the American Association for the Advancement of Science, 110 years ago this month, a primary object was "by periodical and migratory meetings, to promote intercourse between those who are cultivating science in different parts of the United States." The Association's annual meeting, though it continues to change, remains a major activity.

At this year's meeting, in Washington, D.C., the AAAS general symposium, "Moving Frontiers of Science III," and the programs of the 18 AAAS sections will cover the principal fields of science. For the most part, these will be symposia of two to four sessions, with speakers from all parts of the nation and abroad, but eight sections will also sponsor sessions for contributed papers. In addition, some 45 organizations will have their own sessions. Included are 15 national meetings—notably those of the American Astronautical Society, American Meteorological Society, American Society of Naturalists, American Society of Zoologists, Society of Systematic Zoology, History of Science Society, and science teaching societies—and the special or regional meetings of 31 societies. Among this latter group are societies not previously represented, such as the American Society of Photogrammetry, the Instrument Society of America, and the Washington Academy of Sciences. Typical of such special programs are the American Psychiatric Association's projected four-session symposium on hallucinations and the American Physiological Society's symposium on space medicine. Many of the more than 300 sessions will be cosponsored by an additional 40 or more societies.

Particularly important new research findings are often announced at AAAS meetings and new laboratory supplies and instruments and the latest scientific books are displayed in the Annual Exposition of Science and Industry. At this year's meeting a new, much-improved system of closed-circuit, large-screen, color television, lent by Ciba Pharmaceutical Products, Inc., will be demonstrated in a series of special sectional programs. The program of Section B (Physics) is being arranged by a committee headed by Deane B. Judd, of the National Bureau of Standards; those of Section F (Zoological Sciences) and of Section G (Botanical Sciences), by an appropriate committee of the American Institute of Biological Sciences. The program committee of Section N's four-session symposium on congenital heart disease plans sessions that will include models, pathologic specimens, differential diagnostic work-up, and an actual heart operation.

In recent years, the Association has increasingly recognized its responsibility to inform the general public on scientific developments and its obligation to assist all organizations concerned in the encouragement of qualified young people to prepare for, and enter, careers in science. The activities of the AAAS Pressroom and of the local Committee on Public Information, the broadcast coverage of the meeting, and the 12th annual Junior Scientists Assembly—a special program for a large number of selected high-school students, at a site apart from the technical sessions—reflect these objectives.

Meeting Sites

A cholera outbreak, in 1852, and three great wars have interrupted the continuity of the AAAS annual meetings, while a number of additional summer meetings (principally from 1931 to 1941) have also been held. Consequently, this year's large gathering of scientists, teachers, and administrators in Washington will be the 125th, rather than the 111th, annual meeting. It will also be the 7th Washington meeting.

The previous occasions when the AAAS met in the nation's capital were in 1854, 1891, 1902, 1911, 1924, and the centennial year, 1948. Thus the Washington meetings have spanned more than a century. In no city has the Association met more often, and in only three other cities—Boston, where the AAAS was conceived, Philadelphia, where it was founded, and New York—has it met as many as seven times. Meetings have not been more frequent in any one city because the Association has consistently sought, where feasible, to meet in different sections of the nation and Canada and thus serve the convenience of its members.

The physical facilities available, the number and size of the participating societies in any particular year, and the number and variety of local scientific institutions are all major factors in the selection of meeting sites. In this last respect, Washington stands first, when its public and private scientific organizations are considered. There are six large universities and branches of several others in the metropolitan area. Its unique concentration of scientific research and administrative agencies in all the major disciplines make Washington a great national science center. Such large and ramified governmental establishments as the Agricultural Research Center, Army Medical Center, Atomic Energy Commission, Library of Congress, National Academy of Sciences, National Bureau of Standards, National Institutes of Health, National Science Foundation, Naval Medical Center, Naval Observatory, Office of Education, Office of Naval Research, Smithsonian Institution (with its subdivision, the U.S. National Museum), the U.S. Geological Survey, and Weather Bureau employ many thousands of scientists and attract scores of thousands of visiting scientists throughout the year.

Among the private organizations, the Brookings Institution and the Carnegie Institution of Washington, including its Geophysical Laboratory and its Department of Terrestrial Magnetism, also receive many visitors, as do the many scientific, educational, and learned societies that maintain national headquarters in Washington. A complete list of these is too extensive to be provided here, but included are the American Chemical Society, American Institute of Biological Sciences, American Geological Institute, American Geophysical Union, American Psychological Association, Entomological Society of America, Federation of American Societies for Experimental Biology, National Education Association, and National Geographic Society—and the AAAS.

Originally, the offices of the Association were "wherever the secretary hung his hat"; from 1907 to 1946 the Smithsonian Institution generously provided space; then the new headquarters building at 1515 Massachusetts Avenue become a reality. It has been occupied since May 1956. It is anticipated that many members attending this year's AAAS meeting will visit the building, which belongs to all of them. From the hotel reservations already made it is ap-

parent that a high percentage of wives will accompany their husbands to this year's meeting, as they have accompanied them to the six other Washington meetings. For this 1958 meeting, a Committee on Women's Events, headed by Mrs. Alan T. Waterman, is making appropriate plans for tours, a luncheon, and a special visit to the White House.

Earlier Washington Meetings

Some notes on the earlier AAAS meetings in Washington and the scientific personalities of the times and sidelights on such venerable associates in science as the Smithsonian Institution, the National Academy of Sciences, and the National Geographic Society may enhance the pleasure of participants in this year's meeting. The development of the city, of the nation, and of science is indicated in the programs and proceedings of these conventions of the past.

The first Washington meeting, 26 Apr.–3 May 1854, came early in the Association's history. This was only the eighth meeting but, in six years, AAAS membership had grown from 461 charter members to 1004. All activities and sessions were centered at the Smithsonian Institution—in the original castle-like brownstone structure, begun in 1847 and completed in 1855, which still is a serviceable and much-used building. An AAAS office was set up, and the names of the 168 who registered were entered in the book of the Association's permanent secretary, who was Joseph Lovering, professor of physics at Harvard, subsequently to become the Association's 23rd president. Information on "Lodgings, &c." was available at the bookstore of Taylor and Maury, on Pennsylvania Avenue between 9th and 10th streets. The principal hotels used were the old Willard and the National.

At that time there were but two sections. Section A (Mathematics and Physics) was administered by William C. Redfield, the eminent geologist and first elected president of the Association. Section B (Chemistry, Natural History, and Geology) was headed by the celebrated botanist, John Torrey. No less than 110 papers were presented at this meeting, but not all were printed in the proceedings because "some were thought unworthy of publication, and, in other cases, copies were not furnished by their authors." Among the papers were the following: "On Gulf Stream temperatures," by A. D. Bache, Superintendent of the Coast Survey; a chart of recent hurricanes, by William C. Redfield; and "On the relations of the American patent system to the progress of science," by L. D. Gale of the U.S. Patent Office.

In 1854 the president of the Association was Yale's James Dwight Dana, a notable American mineralogist and a son-in-law of Benjamin Silliman. The retiring president was Benjamin Peirce of Harvard, described by F. R. Moulton as the foremost mathematician of his time. In a humorous introduction to his address, "Geometry, the key of the sciences," Peirce made a point of what he described as the already established AAAS custom of "calling out . . . the actor upon the stage after the night of the performance, when the blood is no longer warm." He surveyed the many sciences where mathematics was indispensable. Though this was said to be his first formal speech, he did not grope for words. The address was abundantly filled with the mythological allusions and literary figures of speech so characteristic of a century ago. In eulogizing the satisfying exactness and form of geometry, he said: "The rash system of philosophy which, despising the science it cannot comprehend, presumes to soar capriciously above the well-established theories of inductive demonstration, must melt its ill-cemented pinions as it approaches the source of truth, and sink, like Icarus, into deserved ridicule and contempt."

In commenting favorably on government support of science, the well-established Coast and Geodetic Survey, the National Observatory, the Military and Naval academies, and scientific expeditions, he said: "The time is ripe for some important improvement in the public condition of science and its relations to government."

During the meeting, "the members of the Association were elegantly entertained, on different evenings," by Franklin Pierce, President of the United States, Jefferson Davis, Secretary of War, James Guthrie, Secretary of the Treasury, and William W. Corcoran. Invitations to social occasions were so numerous that the delegates were unable to accept all of them. The delegates did enjoy, however, a steamer excursion to Mount Vernon which the local committee, headed by the Hon. J. W. Maury, had arranged. The local committee included Joseph Henry, first secretary of the Smithsonian Institution and second elected president (1849) of the Association.

Thirty-seven years passed before the second Washington meeting, of 19–26 Aug. 1891. In this interval, the War between the States had caused the lapse of meetings in the years 1861–65 and had seriously affected AAAS membership. It was not until 1879 that the roll of members returned to the 1854 level. By 1891, however, at the time of the 40th meeting, the Association had 2054 members, or twice as many as at the time of the first Washington meeting. About 500 were residents of the Washington area—a figure which indicated the continuing growth of the governmental agencies employing scientists.

Albert B. Prescott, distinguished chemist of the University of Michigan, was president of the AAAS at this time. In the opening session he replied to the welcoming speeches of Edwin Willits, Assistant Secretary of Agriculture, and J. C. Welling, president of Columbian (now George Washington) University, where most of the sessions were held. In his reply Prescott referred to such past presidents and charter members of the Association as A. D. Bache, who took charge of the Coast Survey in 1834 and served for 24 years, and Joseph Henry, first secretary of the Smithsonian Institution, from 1846 until his death in 1878. Spencer F. Baird, naturalist of the Smithsonian, had died in 1887. In comment, Prescott said: "There is no greater need in this land—unless it be the exclusive need of righteousness itself—than the advancement of science. Let this be understood by all, if America is not to fall short in the nurture of manhood, in the reach of mind and in the arts of peace, if she is not to fall short altogether, she must advance in science and must cherish her writers in scientific research."

The number of AAAS sections had increased to eight by 1891, and each vice president gave an address. Among these were the following: Section B (Physics), "The ether," by Francis E. Nipher, of Washington University; F (Biology), "The future of systematic botany," by John M. Coulter, president of Indiana University; I (Social and Economic Sciences), "The farmer and taxation," by Edmund J. Jones, of the University of Pennsylvania.

The AAAS retiring presidential address, "Useful plants of the future," was given by George Lincoln Goodale, well-known botanist of Harvard. In outlining some of the potentialities of economic botany Goodale did not foresee the synthetic fibers of today. John M. Macfarlane of Edinburgh gave a lecture at the National Museum on "Illustrations of heredity in plant hybrids."

The second Washington meeting was elaborately organized through the coordinated work of the permanent secretary, F. W. Putnam, Harvard anthropologist, who had assumed the AAAS office in 1873, and the local committees, that represented a joint commission of five scientific societies in Washington. Colonel Garrick Mallery (U.S. Army), assigned to the Bureau of Ethnology, served as general chairman, and Marcus Baker (U.S. Geological Survey), as secretary. Some of the other members included F. W. Clarke, Henry Gaumet, C. Brown Goode, Everett Hayden, L. O. Howard, Gardiner G. Hubbard, S.

P. Langley, T. C. Mendenhall, C. Hart Merriam, Simon Newcomb, Richard Rathbun, Harvey W. Wiley (AAAS general secretary), and Edwin Willits. The committee members wore identifying ribbons of different colors, a 32-page guidebook was specially printed and distributed, the "programme" had 192 pages, and the convention badges had numbers instead of names (the numbers could be checked against names in the AAAS office). A cumulative list of the names and addresses of the 653 registrants was printed each day. The registrants came from 37 states, the District of Columbia, and ten foreign countries.

Among the 227 papers read were papers on color photography, artificial rain, uses of fermentation tubes in bacteriology (by Theobald Smith), what our fundamental units should be, atomic theory, and "mechanical methods used in computing data of the 11th U.S. Census" (by John S. Billings, surgeon, U.S. Army). Apparently the use of punch cards had been suggested by Billings as early as 1880; subsequently they were improved by Herman Hollerith of the Census Bureau. C. Brown Goode (director, U.S. National Museum) gave an address on the first scientific congress held in Washington in 1844.

The headquarters hotel was the Arlington, at Vermont Avenue between H and I Streets, one block from Columbian University. Other nearby hotels which housed delegates were the Arno, Ebbitt House, Randall, and Fredonia. Coaches pulled by two, four, or six horses, with capacities for 12, 20, or 32 persons, respectively, were available at $10 to $20 per day for excursions to Glen Echo, Mount Vernon, and Luray Caverns. President Benjamin Harrison was out of town, but the private part of the White House grounds, by his order, was made available for a reception, at which the Marine Band played nine selections, including the William Tell overture and, in conclusion, Hail Columbia. The souvenir program had silken cords and tassels. There was a reception at the Arlington Hotel, sponsored by the Board of Trade, as well as an entomologists' reception at the home of C. V. Riley, and numerous smaller parties. Alice C. Fletcher, chairman of the Ladies Reception Committee (composed of members of the Women's Anthropological Society of America) made arrangements for visiting women.

Among the items of business passed by the AAAS Council were the appointment of a committee on standards of astronomical and physical units, including S. P. Langley and others; continuation of the Committee on Indexing Chemical Literature; support of greater uniformity in biological nomenclature; advice to the U.S. Department of Agriculture on national water management; a request to Congress to establish a national arboretum; and an endorsement of the principle of federal support, each year, of an American table at the Naples Marine Biological Station. The AAAS had contributed $100 for this purpose in 1891—a substantial sum in view of its income of $7443.08 for that year.

Christmas Meetings

The Association's 52nd meeting—the third Washington meeting—was the first AAAS meeting to be held in December. The period 29 Dec. 1902–3 Jan. 1903 was selected as an experiment to accommodate a growing number of affiliated societies which wished to meet with the then ten sections of the Association. The American Society of Naturalists and many of the biological societies had already changed to a December date. The underlying reason for the change for these groups and for the AAAS was the rapid increase in academic summer sessions, in which faculty members taught, which would conflict with meetings held in August. The Christmas holiday period was the one time in the year when virtually all academic institutions suspended classes. Incidentally, more than 50 universities cooperated by reopening a day or two later than usual, in view of the 3 January closing date of the meeting. With 989 registrants, plus 363 additional registrations among the 23 participating societies, the third Washington meeting was one of the largest held up to that time and was considered a decided success.

Thus began the "traditional Christmas meetings of the AAAS." Except for the special war-year meetings—the meeting held in Cleveland in September 1944 and the "1945" meeting, delayed until March 1946, and held in St. Louis—and the centennial celebration, the AAAS annual meeting has since been held in the last week in December.

In 1902 the AAAS president was Ira Remsen, also president of the American Chemical Society and of Johns Hopkins University. At the opening session in St. Matthews Church, 15th and H Streets, Remsen gracefully responded to addresses of welcome from paleontologist Charles D. Walcott, director of the U.S. Geological Survey, representing the Washington Academy of Sciences; from Henry B. F. MacFarland, president of the District of Columbia Board of Commissioners, for the District; and from David J. Hill, Assistant Secretary of State, for the national government. Hill said, "In the United States there is and can be—and it is something to be thankful for—no such thing as official science." Charles W. Needham, president of Columbian University, where most of the sessions were held, gave the concluding speech of welcome for all of the universities of the area.

After a luncheon at the Arlington Hotel, tendered by the local committee, two series of concurrent vice-presidential addresses were given. Among these, W. S. Franklin, of Section B (Physics), in his "Popular science," took issue with Woodrow Wilson, the new president of Princeton, who had said that he found the methods of science too prevalent. Charles C. Nutting, of Section F (Zoological Sciences), in "The perplexities of a systematist," pointed out that "there will always be need for the men who perform the hard and often thankless task of the systematist." William H. Welch (Johns Hopkins) spoke on "The origin and aims of the new section on physiology and experimental medicine." In the evening of this first day, Asaph Hall (U.S. Navy) gave his retiring AAAS presidential address, "The science of astronomy."

Among the 360 papers read were "The theory of non-spherical surfaces in the construction of telescope objectives," by F. R. Moulton; "On the velocity of light as affected by motion through the ether," by Edward W. Morley and Dayton C. Miller; "The magnetic and electric deviation of the easily absorbed rays from radium," by E. Rutherford; "The metric system," by J. Burkitt Webb; "The drainage problems of irrigation," by C. G. Elliott; "Mount Pelée—the eruptions of August 24 and 30, 1902," by Angelo Heilprin; and "Some recent cytological investigations and their bearing on Mendel's principles of heredity," E. B. Wilson. A particularly important program was the discussion sponsored by the American Society of Naturalists, "How can endowments be used most effectively for scientific research?" The discussants were T. C. Chamberlin, William H. Welch, Franz Boas, W. M. Wheeler, Conway MacMillan, and Hugo Münsterberg.

Members of the local committees were distinguished and able. President Theodore Roosevelt was honorary general chairman, and Charles D. Walcott, who became AAAS president in 1923, was the active general chairman. Gilbert H. Grosvenor of the National Geographic Society was a member of the executive committee and chairman of the transportation committee. At this time, L. O. Howard, renowned entomologist, was permanent secretary of the Association, the membership of which had by now reached 3474. This increase was partly due to the fact that *Science*, owned and published by J. McKeen Cattell, had, in 1900, become the official journal of the AAAS and was sent to all members.

Again the Arlington was headquarters hotel, but the New Willard, Raleigh, Shoreham (then at 15th and H Streets),

Hamilton, Colonial, and others were also used for housing. Not only were cabs and victorias, drawn by one or two horses, in plentiful supply, but automobiles could be hired. Preliminary announcements explained that, in Washington, "The Avenues, named after the States, cross the Streets diagonally but will give little trouble to the visitor." Social events and public lectures were numerous. The trustees of the Corcoran Gallery of Art and the local committee sponsored a reception, and some 500 delegates were received at the White House by President Roosevelt.

The AAAS Council transacted a considerable amount of business: There was one resolution on the death of Walter Reed in recognition of his successful studies on yellow fever and another stipulating that one member of the Isthmian Canal Commission should be a properly qualified medical man. The terms of section secretaries and committeemen-at-large were fixed at five years, for better continuity.

The pattern of the 63rd, and fourth Washington, meeting, 27–30 Dec. 1911, was essentially similar to that of the meeting held nine years earlier, but science was becoming increasingly specialized and scientists were more numerous. There were 1306 registrants and an estimated 1500 others who attended. Fortunately, a new advance registration system combined with dues payment in advance had been inaugurated, and, although members had to exchange cards for programs and badges, waiting time was eliminated. Besides the eleven sections, 31 affiliates and other societies had programs; 860 papers were read. In the preceding nine years the Association's membership had almost tripled, and it now stood at 8041.

The new Willard was headquarters hotel; twelve other hotels were required to house the out-of-town delegates. Rates, for single rooms without meals, were $1 to $2.50 without private bath; $2 to $3.50 with bath. The 163 sessions, necessarily, were held in a variety of sites: the Willard, Raleigh, and Ebbitt hotels; Business and McKinley high schools; the U.S. National Museum and the Bureau of Standards; Hubbard Memorial Hall of the National Geographic Society; the Carnegie Institution; the Cosmos Club; St. John's parish hall; the Public Library; Georgetown University Law School; and George Washington University Medical School.

On the first night, AAAS president Charles E. Bessey (University of Nebraska), noted botanist, presided at the welcoming speech of President William Howard Taft, who compared the scientists' search for truth with the approach of judges hearing cases. His remarks were followed by the AAAS retiring presidential address of A. A. Michelson (University of Chicago), Nobel prize winner in physics, who spoke on "Recent progress in spectroscopic methods." The Honorary Reception Committee, headed by President Taft, included Alexander Graham Bell, Herbert Putnam, Elihu Root (a member of the AAAS), A. Lisner, and Chief Justice White.

Honorary chairman of the fourth Washington meeting was Robert S. Woodward, president of the Carnegie Institution; the general chairman was Frank Wigglesworth Clarke, president of the Washington Academy of Sciences. Charles D. Walcott, who had become secretary of the Smithsonian Institution, was chairman of the Finance Committee. Mrs. R. S. Woodward was chairman of the Ladies Reception Committee. L. O. Howard was still permanent secretary of the Association; F. S. Hazard of the staff was responsible for the details of the meeting.

Organized tours were a feature, a special exhibition cavalry drill at Fort Myer was arranged, and a reception was held at the Corcoran art gallery. A number of the government agencies and several private institutions had special exhibits and open houses or receptions, and the larger local scientific societies held smokers in the hotels. Among the vice-presidential addresses were the following: A. L. Rotch of Section D (Mechanical Science and Engineering) spoke on "Aerial engineering"; R. A. Harper of Section G (Botanical Sciences), on "Some current conceptions of the germ plasm"; and U.S. Senator from Ohio Theodore E. Burton of Section I (Social and Economic Sciences), on "The cause of high prices."

The AAAS Council recommended the passage of a national quarantine and inspection law against the introduction of injurious insects and plant diseases and the creation of a Bureau of Astronomy, and reaffirmed its previous approval of a national department of public health.

The 79th, or fifth Washington, meeting, held 29 Dec. 1924–3 Jan. 1925, with a registration of 4206, not only was the largest AAAS meeting up to that time but is still exceeded in attendance only by such recent meetings as the New York meetings of 1949 and 1956 (with 7014 and 5327 registrants, respectively) and the Chicago meeting of 1947. The Association had adopted a plan of holding a particularly comprehensive convention of the affiliated societies every four years in a major city. Among the 49 participating organizations were such large groups as the mathematicians, the American Physical Society, the Washington section of the American Chemical Society, the biological societies (including the phytopathologists and the Entomological Society of America), the American Anthropological Association, the American Psychological Association, the Society of American Bacteriologists, most of the societies now constituting the Federation of American Societies for Experimental Biology, and the agricultural societies. The memberships of all these groups have now expanded to the point where it would be physically impossible for the larger societies to meet together in any one city.

Commensurate with the size and complexity of the 1924 meeting were the arrangements for it. Under the general direction of the permanent secretary, Burton E. Livingston (Johns Hopkins), Sam Woodley was in charge of the physical arrangements; Sam F. Trelease, University of Louisville, edited the 248-page "General Program," in which the same key symbols used today were employed; Austin H. Clark (U.S. National Museum), assisted by his colleagues W. N. Mann and W. P. True, were in charge of all press-room arrangements, including radio—used for the first time as an integral part of the meeting.

Though there had been a few commercial exhibits for some years, the Annual Exposition of Science and Industry was set up on an organized professional basis for the first time. Charles A. Shull (University of Chicago) issued the invitations to prospective exhibitors, and W. J. Showalter (National Geographic Society) allotted booth space and made all local arrangements. The main Exposition was placed in the George Washington University gymnasium. There were supplementary nonprofit exhibits, notably in medicine, that were adjuncts to the session rooms.

William Mather Lewis, president of George Washington University, was general chairman of a local committee that included C. G. Abbott (Smithsonian Institution), Gilbert H. Grosvenor (National Geographic Society), Vernon Kellogg (National Research Council), John C. Merriam (Carnegie Institute of Washington), and David White (National Academy of Sciences). There were six subcommittees, and each of the 15 sections had local representatives. Among the latter were Lyman J. Briggs, Paul D. Bartsch, and R. F. Griggs.

J. McKeen Cattell, president of the Association, presided at the opening session in Memorial Centennial Hall on 17th Street, when Charles Evans Hughes, Secretary of State, gave an address on "Some aspects of international cooperation." The address of retiring AAAS president Charles D. Walcott was on "Science and service." The reception which followed, in the new National Museum, was sponsored by 600 local members of the AAAS. Later in the meeting period, at the White House, President Calvin

Coolidge received members and guests and gave an address of welcome. Among seven other afternoon or evening addresses was the third annual Sigma Xi address, given by Frederick Fuller Russell, general director of the International Health Board. There were 1781 papers and 12 vice-presidential addresses.

The second Newcomb Cleveland Prize was divided between L. R. Cleveland, for two papers on the symbiosis of termites and their intestinal flagellate protozoa, and Edwin P. Hubble, for his paper "Cepheids in spiral nebulae."

Again the Willard was AAAS headquarters, and many other hotels were used. Sessions were as widely scattered as in 1911, with the Brookings Institution, the National Academy of Sciences, the Weather Bureau, U.S. Department of the Interior, and the city high schools pressed into service. (At the last, a "no smoking" rule was enforced.) Trolley tokens had risen from six for a quarter to six for 40 cents since the previous meeting. Social events were numerous. The Biologists' Smoker was jointly sponsored by the AAAS and the Union of Biological Societies; the Columbian Women of George Washington University gave a reception and dance; the National Geographic Society entertained visiting geographers, and the American Association of University Women and College Women's Club had "at homes."

Some of the actions taken by the AAAS Council were approval of any improvement in the calendar that would adjust it to modern conditions for scientific work; endorsement of the Navy program for oceanographic study; and approval of the proposed national arboretum. The sum of $500 was voted to the Union of Biological Societies to assist in the founding of *Biological Abstracts*.

A few of the authors of papers at the 1924 meeting who are expected to attend the 1958 meeting are F. O. Rice, now chairman of Section C, whose paper then was on "Catalysis in homogeneous systems"; H. H. Plough, now chairman of Section F, who discussed "A self-fertile strain of *Drosophila* which is partially sterile in outcrosses"; and A. Irving Hallowell, now chairman of Section H, who discussed "Some observations and measurements of the Indians of Labrador."

Centenary

The sixth Washington meeting, held 13–17 Sept. 1948—the 115th national meeting of an association celebrating its centenary—is too recent to require a detailed account. It was an exceptional meeting date for an exceptional occasion—the centennial of the founding of the AAAS in Philadelphia, in September 1848.

The meeting was exceptional in other respects. There were no sectional pro-

grams as such, though the principal disciplines were included. Completely absent were the scores of sessions for contributed papers of the participating societies—because there were no participating societies. To make possible this one special meeting, the societies had been asked to arrange separate sessions—preferably, immediately preceding the AAAS centenary. In cooperation, the biological societies met in Washington 10–13 September.

The five-day AAAS meeting, as arranged by the program committee, headed by retiring president Harlow Shapley, was devoted to 14 important symposia in the mornings; to an extensive series of afternoon tours to the area's scientific institutions, public and private; and to 17 illustrated lectures and addresses in the evenings.

The Annual Exposition of Science and Industry was not held at this meeting, but there were special exhibits on display at many of the governmental agencies visited during the tours.

The theme of the meeting was "One world of science." The keynote paper, with this title, written by AAAS president Edmund W. Sinnott, explained that the emphasis of the celebration was not on the origins of the AAAS but on the current status of science—and of man. The theme, he wrote, carried "no thought of speed or power, no threat of destruction or promise of paradise. On the contrary it [implied] that science is the same everywhere throughout the world, and . . . that the universe is orderly."

Each symposium had three papers and several discussants, and there was an opportunity for selected written questions from the audience to be considered. Most of the symposia centered on the world's resources of minerals, food, and energy and on the health and future of mankind. Necessarily, the symposia were in concurrent groups of three or four. The proceedings of all but one of these symposia were subsequently published in an attractive quarto volume, *Centennial*, a few copies of which are still available.

On the first evening, in Constitution Hall, President Harry S. Truman gave an appropriate address of welcome and commentary on the state of science, at which most of the 2734 registrants were present. Harlow Shapley's AAAS presidential address, "One world of stars," came next. The reception that followed was held in the Pan American Union. There were refreshments and music by the U.S. Air Force Band.

The lectures and addresses on the remaining evenings were also in concurrent groups of four or five and, like the symposia, were held in the headquarters hotel, the Statler, and in the larger auditoriums in downtown Washington.

The tours, arranged by a committee

chaired by Raymund L. Zwemer, proved deservedly popular.

The general chairman of the sixth Washington meeting was F. R. Moulton, completing his last year as AAAS administrative secretary, before retirement. The assistant administrative secretary was John M. Hutzel, who was also soon to leave the Association. A meeting of this exceptional pattern would have been impossible without the personal services and interest of the many scientists who served on the local committees or who were on the staffs of the more than 40 local scientific organizations and institutions. Historical vignettes of the cooperating agencies were published in *Science,* and an excellent survey of science in Washington was written for the gold-lettered, green-covered souvenir program by Paul H. Oehser. Included were sketches on the beginnings of the Smithsonian Institution, the National Academy of Sciences, the U.S. Department of Agriculture, the U.S. Geological Survey, and other agencies.

Not only was the centennial meeting (under the chairmanship of the late Austin H. Clark, assisted by Sidney S. Negus, Watson Davis, and Gorda Hubble) well reported in the press but there were network programs on radio and television. In retrospect, the 1948 meeting stands out as an earnest attempt to survey the impact of science and man's future.

During the centennial year there was an elaborate and successful campaign to increase the Association's membership. Over 200 committees throughout the country worked hard and effectively. The membership figures for the beginning and end of 1948 were 33,442 and 42,545, respectively—a net gain of more than 9000 members.

The growth of the Association continues. At the end of 1957, the Association's membership stood at 55,727. By the end of this 110th year, it is hoped that it will at least reach 60,000. In the past ten years the number of affiliated societies has increased from 207 to 279. The AAAS sections now number 18, with the activation of Section P (Industrial Science) in 1951 and the assumption of full sectional status by Nd (Dentistry) and Np (Pharmacy) in 1954. In the past few years, the AAAS has undertaken a variety of important new activities, and others are in prospect.

The seventh Washington meeting, of 26–31 Dec. 1958, will be a significant and memorable addition to the earlier meetings held in the nation's capital.

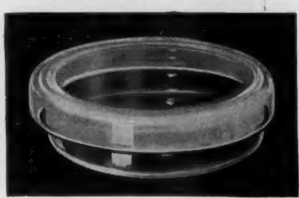
RAYMOND L. TAYLOR
American Association for the Advancement of Science

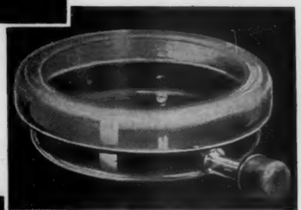
Pan American Sanitary Conference

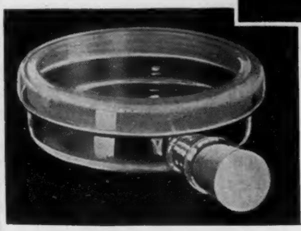
More than 200 public health projects will be examined and a comprehensive program and budget for 1959 adopted at the fifteenth Pan American Sanitary Conference that is to meet 21 September through 6 October in San Juan, Puerto Rico. It will be attended by public health ministers and leading health authorities of the Western Hemisphere.

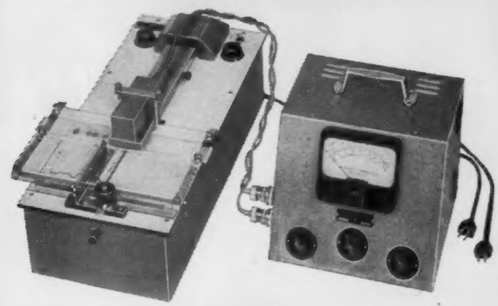
The conference, which is held every 4 years, is the supreme governing body of the Pan American Sanitary Organization—the regional organization in the Americas of the World Health Organization. The conference will elect the director of the Pan American Sanitary Bureau, executive organ of the PASO, to a term of 4 years commencing 1 February 1959. The present incumbent, Fred L. Soper, completes his third term in office on 31 January 1959.

The organization, serving as international coordinator and technical adviser, as catalytic agent and as information clearing house for the national health services, operates in practically all areas of public health. These embrace the promotion of disease eradication and control in malaria, tuberculosis, venereal disease and treponematoses such as yaws, the endemo-epidemic diseases, and pub-









lic health administration, nursing, social and occupational health, maternal and child health, mental health, nutrition, environmental sanitation, health aspects of atomic energy, public health education and training, and health education of the public.

The conference will review the organization's program of fellowships, seminars and training courses, a major means used to help overcome grave shortages of trained public health personnel in most countries, and for strengthening the national health services. Over the past 4 years 1532 fellowships have been granted in this hemisphere; 552 fellows received support during the past year.

Psychopharmacology

The Psychopharmacology Service Center of the National Institute of Mental Health is sponsoring a conference on Child Research in Psychopharmacology, to be held at the Hotel Statler, Washington, D.C., 27–28 October. The primary objectives of the conference are: to focus on basic problems, including methodology and measuring instruments; to develop new hypotheses and approaches to the study of drug effects in children; to prepare the groundwork for initiating long-term developmental studies; and to stimulate further research interest in this important area. The conference participants will consist of representatives from the fields of psychology, psychiatry, pediatrics, social work, and neurophysiology.

Although the second day will be a closed session, a limited number of interested observers will be admitted *by advance registration* to the opening session on 27 October. Requests for attendance and further details should be addressed to Dr. Seymour Fisher, Psychopharmacology Service Center, National Institute of Mental Health, Bethesda 14, Md.

Forthcoming Events

October

19–22. Land and Water, Soil Conservation Soc. of America, 13th annual, Asheville, N.C. (H. W. Pritchard, 838 Fifth Ave., Des Moines 14, Iowa.)

19–24. American Soc. of Anesthesiologists, Pittsburgh, Pa. (J. E. Remlinger, 802 Ashland Ave., Wilmette, Ill.)

19–26. Allergology, 3rd intern. cong., Paris, France. (S. M. Feinberg, Medical School, Ward Memorial Building, 303 East Chicago Ave., Chicago, Ill.)

19–26. Medical Hydrology, 21st intern. cong., Madrid, Spain. (Dr. Francon, 55, rue des Mathurins, Paris 8e, France.)

19–28. Society of Motion Picture and Television Engineers, 84th conv., Detroit, Mich. (SMPTE, 55 W. 42 St., New York, N.Y.)

20–21. Rubber and Plastics Instrumentation, natl. symp., Akron, Ohio. (D. R.

Davis, General Tire and Rubber Co., Central Research Lab., Akron 9.)

20–22. American Oil Chemists' Soc., fall, Chicago, Ill. (Mrs. L. R. Hawkins, 35 E. Wacker Drive, Chicago 1.)

20–23. American Acad. of Pediatrics, Chicago, Ill. (E. H. Christopherson, 1801 Hinman Ave., Evanston, Ill.)

20–23. American Psychiatric Assoc., Kansas City, Mo. (1700 18 St., NW, Washington 6.)

21. American Soc. of Safety Engineers, annual, Chicago, Ill. (J. B. Johnson, 425 N. Michigan Ave., Chicago 11.)

22–24. American Assoc. of Petroleum Geologists, southwestern, Mineral Wells, Tex. (R. H. Dott, Box 979, Tulsa 1, Okla.)

22–24. American Vacuum Society, 5th natl. symp., San Francisco, Calif. (D. Gustin, P.O. Box 1282, Boston 9, Mass.)

22–24. Aviation Medicine, 4th annual symp., Santa Monica, Calif. (T. H. Sternberg, UCLA Medical Center, Los Angeles 24, Calif.)

22–26. American Soc. for the Study of Arteriosclerosis, annual, San Francisco, Calif. (O. J. Pollak, P.O. Box 228, Dover, Del.)

23. Organic Chemistry, 5th biennial symp., Philadelphia, Pa. (D. Glusker, Rohm and Haas Co., 5000 Richmond St., Philadelphia 37.)

23–25. National Soc. of Professional Engineers, San Francisco, Calif. (K. E. Trombley, NSPE, 2029 K St., NE, Washington 6.)

23–25. Rocket Technology and Astronautics, intern., Essen, Germany. (Deutsche Gesellschaft fuer Raketentechnik und Raunfahrt, e.v., Neunsteinerstrasse 19, Stuttgart, Zuffenhausen.)

24–25. International Conference on the Insulin Treatment in Psychiatry, New York, N. Y. (M. Rinkel, 479 Commonwealth Ave., Boston 15, Mass.)

24–25. Taxonomic Consequences of Man's Activities, symp., Mexico, D. F. (H. C. Cutler, Missouri Botanical Garden, St. Louis.)

24–28. American Heart Assoc., San Francisco, Calif. (J. D. Brundage, 44 E. 23 St., New York 10.)

27–28. Child Research in Psychopharmacology, conf., Washington, D.C. (S. Fisher, Psychopharmacology Service Center, Natl. Inst. of Mental Health, Bethesda 14, Md.)

27–28. Plant Physiology, 9th annual research cong., Saskatoon, Saskatchewan, Canada. (D. T. Coupland, Plant Ecology College of Agriculture, Univ. of Saskatchewan, Saskatoon.)

27–29. Radio, Institute of Radio Engineers, fall meeting, Rochester, N.Y. (V. M. Graham, EIA, 11 W. 42 St., N.Y.)

27–29. Weak Interactions, APS conf. (by invitation), Gatlinburg, Tenn. (J. L. Fowler, ORNL, P.O. Box X, Oak Ridge, Tenn.)

27–31. American Inst. of Electrical Engineers, fall general, Pittsburgh, Pa. (N. S. Hibshman, AIEE, 33 W. 39 St., New York 18.)

27–31. American Public Health Assoc., St. Louis, Mo. (B. F. Mattison, 1790 Broadway, New York 19.)

27–31. Metal Exposition and Congress, 40th natl., Cleveland, Ohio. (ASM, 7301 Euclid Ave., Cleveland 3.)

27–31. Vertebrate Speciation Conf., Univ. of Texas, Austin. (W. F. Blair, Dept. of Zoology, Univ. of Texas, Austin 12.)

27–1. Mental Health, 3rd Latin American cong., Lima, Peru. (B. Caravedo, Comite Peruano Organizador, III Congreso Latinoamericano pro Salud Mental, Avenida del Golf 1040, San Isidro, Lima.)

29–30. '58 Computer Applications, symp., Chicago, Ill. (M. J. Jans, Armour Research Foundation, 10 W. 35 St., Chicago 16.)

30–31. Plastics, intern. symp., Philadelphia, Pa. (ASTM, 1916 Race St., Philadelphia 3.)

30–1. American Assoc. of Textile Chemists and Colorists, 37th natl. conv., Chicago, Ill. (J. G. Kelley, E. I. duPont de Nemours & Co., Inc., 7 South Dearborn St., Chicago 3.)

November

2–7. Radiology, 6th Pan American cong., Lima, Peru. (M. Lesende, Inter-American College of Radiology, Tucuman 1516, Buenos Aires, Argentina.)

3–4. Italian Soc. of Nuclear Biology and Medicine, 3rd cong., Florence, Italy. (Segreteria della Societá Italiana di Biologia e Medicina Nucleare, Clinica Medica, Pisa, Italy.)

4. Use of 650 and 704 Computers for Structure Analysis, conf., Pittsburgh, Pa. (G. A. Jeffrey, Dept. of Chemistry and Physics, Univ. of Pittsburgh, Pittsburgh 13.)

4–7. American Soc. of Tropical Medicine, Miami Beach, Fla. (R. B. Hill, 3575 St. Gaudens Rd., Miami 33.)

4–11. International North Pacific Fisheries Commission, 5th annual (by invitation), Tokyo, Japan. (R. I. Jackson, 209, Wesbrook Building, Univ. of British Columbia, Vancouver 8, Canada.)

5–7. Society of Rheology, annual, Philadelphia, Pa. (W. R. Willets, Titanium Pigment Corp., 99 Hudson St., New York 13.)

6–7. Nuclear Science, 5th annual, San Mateo, Calif. (H. Pratt, IRE, 1 E. 79 St., New York 21.)

6–8. Geochemical Soc., St. Louis, Mo. (K. B. Krauskopf, Geology Dept., Stanford, Calif.)

6–8. Geological Soc. of America, St. Louis, Mo. (H. R. Aldrich, 419 W. 117 St., New York 27.)

6–8. Gerontological Soc. 11th annual scientific meeting, Philadelphia, Pa. (N. W. Shock, Baltimore City Hospitals, Baltimore 24, Md.)

6–8. Paleontological Soc., St. Louis, Mo. (Miss K. V. W. Palmer, 109 Dearborn Pl., Ithaca, New York.)

6–8. Society of Economic Geologists, St. Louis, Mo. (H. M. Bannerman, U.S. Geological Survey, Washington 25.)

8. Society for the Scientific Study of Sex, 1st annual, New York, N.Y. (R. V. Sherwin, 1 E. 42 St., New York 17.)

8–13. International Rubber Conf., Washington, D.C. (B. S. Garbey, Jr., Pennsalt Chemical Corp., 813 Lancaster Pike, Wayne, Pa.)

10–12. American Petroleum Inst., 38th annual, Chicago, Ill. (API, 50 W. 50 St., New York 20.)

10–12. Physics and Medicine of the Atmosphere and Space, intern. conf. (by invitation), San Antonio, Tex. (Southwest Research Center, 331 Gunter Bldg., San Antonio.)

10–13. American Dental Assoc., Dallas, Tex. (H. Hillenbrand, 222 E. Superior St., Chicago, Ill.)

12–14. Society for Experimental Stress Analysis, annual, Albany, N.Y. (W. W. Murray, P.O. Box 168, Central Square Sta., Cambridge 39, Mass.)

12–15. Society of Naval Architects and Marine Engineers, 66th annual, New York, N.Y. (W. N. Landers, SNAME, 74 Trinity Pl., New York 6.)

16–21. Radiological Soc. of North America, Chicago, Ill. (D. S. Childs, 713 E. Genesee St., Syracuse, N.Y.)

16–23. Scientific Information, intern. conf., Washington, D.C. (Mrs. M. Sheppard, Intern. Conf. on Scientific Information, Natl. Acad. of Sciences–Natl. Research Council, 2101 Constitution Ave., Washington 25.)

17–20. Conference on Magnetism and Magnetic Materials, Philadelphia, Pa. (H. B. Callen, Dept. of Physics, Univ. of Pennsylvania, Philadelphia.)

18–20. Air Pollution, 1st natl. conf., Washington, D.C. (Dept. of Health, Education, and Welfare, U.S. Public Health Service, Washington 25.)

Letters

Creativity and Age

Harvey C. Lehman's painstaking studies on the subject creativity and age [see *Science* **127**, 1213 (1958)] graphically express the fact that most creative work is performed at an early age. This is a very disturbing fact when taken at its face value. Psychologically, it would mean that a scientist does not develop after, say, age 39. Conceptually, it has the strangest implications with regard to the relationship between science and experience. Presumably, as a scientist ages he acquires more experience, but this apparently does not help him in creatively contributing to science.

Lehman does not extend his work to any such conclusions; he purposely limits himself to statistics. Yet, he would like to see his results used as the basis for some kind of action; he indicates that in the cited article. However, his only conclusion is akin to the ancient device *carpe diem*—and not much more. If we wanted to arrive at further conclusions, we would have to know about the causes responsible for the statistical facts. In view of the wide implications I mentioned, I should like to point out two of the causes for Lehman's undoubtedly established facts: (i) The biographies of individual "great" chemists—and other scientists as well—show that, as these men grew older, administrative and public duties absorbed an increasing amount of energy previously applied to scientific work. Therefore, age in itself is not necessarily cause for creative decline. (ii) The men who remained creative during a long life were frequently those who changed their fields. Richard Willstätter did it within chemistry when he went from chlorophyll to anthocyanins and to enzymes. Wilhelm Wundt started in medicine and physiology, then turned to philosophy and to psychology.

It is certainly good for society to have administrators who have demonstrated creative abilities, and it may often be advantageous to change from one scientific field to another one. Lehman would give deeper meaning to his statistics if he would carefully weigh the individual factors and causes. He would then also arrive at a better means for judging who were the "greatest" chemists, and for his "statistical" choice of Berzelius and Dumas, he might then find reasons to substitute others.

EDUARD FARBER

Washington, D.C.

I fully agree with Farber's assertion that age in itself is not necessarily a cause of creative decline. I thought I made that point clear in my article. I disagree, however, with his statement that I chose Berzelius and Dumas as the "greatest" chemists. My article refers to them as two "great" chemists—not as the two "greatest" chemists.

If, prior to writing the above letter, Farber had turned to my book, *Age and Achievement* (Princeton University Press, 1953) (as was suggested in my article), he would have found (pages 328 ff.) a list of 16 *general* causative factors which help to account for my statistical findings but which I omitted from my article because I had already published them in my book. *Individual* causative factors are a far more difficult matter to deal with, for the simple reason that causes rarely operate singly.

Here are some reasons why I did not try to investigate *individual* causes. Many psychologists doubt that the individual is fully aware of his own deepest motivations; surface behavior is not always a dependable guide to the serious student of human behavior; the psychoanalysts would scorn any explanation of causative factors that fails to take subconscious factors into account; and there must also be social and economic as well as a host of other causative factors at work. It is also true that thumbnail sketches such as Farber submits in his letter are oversimplifications and are not very illuminating.

To date I have published more than 400 age curves, selected as the most

representative and most revealing from among a total of several thousand curves that I have made which set forth the relationship between age and creative achievement. These curves were obtained by study of the accomplishments of over 30,000 individuals—more than half of the creative "greats" of Christendom. When duplicate names and the names of living persons are deleted, the total number of individual achievers is still quite large. Not all of my data have been analyzed as yet, and my task is not yet ended. I say all this not boastfully, but merely to point out that it is impossible for any one investigator to do everything.

In criticizing a research report it is more important to note whether the investigator has achieved his goal than to say that he should have selected other goals or additional goals. Although Farber mildly chides me because I did not set for myself goals that he would have set, and although it is his privilege to do so, his criticism is not at all relevant to the integrity of my findings. When he asserts that I did not "carefully weigh individual factors and causes," I can only say in reply that that statement is correct.

HARVEY C. LEHMAN
Department of Psychology,
College of Arts and Sciences,
Ohio University, Athens

Soviet Scientific Literature

I have read with great interest the article "American use of Soviet medical research," by Saul Herner [*Science* **128**, 9 (1958)]. While my experience with Soviet scientific literature is in the fields of chemistry and related sciences, some 27 years of experience lead me to conclusions very similar to those of Herner. Much of the work is excellent, some is indeed mediocre. Some bears the earmarks of plagiarism from previously published Western work, but some is also pathbreaking.

From my point of view as an abstractor for *Chemical Abstracts,* one of the most exasperating things about Soviet scientific literature is the carelessness of the editing. Frequently references to the literature contain typographical errors, and typographical differences between what would appear to be the same mathematical equation on different pages have more than once cost me considerable time in rechecking a derivation.

Soviet book reviews I have in general found to be very detailed and critically analytical. Unlike journal articles, they do at times tend toward the nationalistic and political.

FRANZ H. RATHMANN
School of Chemical Technology,
North Dakota Agricultural College,
Fargo

Equipment

The information reported here is obtained from manufacturers and from other sources considered to be reliable. Science *does not assume responsibility for the accuracy of the information. A coupon for use in making inquiries concerning the items listed appears on page 682.*

■ AIR-SAMPLING KIT for measuring lead concentration in air uses a small can of liquefied gas as its power source. The device includes a charcoal trap, midget impinger, and pump. Air samples are drawn into a glass scrubber containing an iodine solution to react with lead. The kit weighs 4.5 lb. A 1-lb container of Freon provides enough power for two samples. (Union Industrial Equipment Corp., Dept. 330)

■ SIGNAL GENERATOR is comprised of a power supply and interchangeable oscillators covering frequencies from 20 to 3000 Mcy/sec in five ranges. Two modulator units offer the option of high- or low-power operation in the 500- to 1000-Mcy/sec range. Frequency accuracy is ±0.5 percent; stability ±0.1 percent. (B. J. Electronics, Dept. 332)

■ POWER SUPPLY, transistorized and regulated, furnishes 0 to 300 v at 0 to 1 amp. Regulation for line changes from 105 to 125 v is ±0.01 percent; for load changes, less than ±0.01 percent or ±0.002 v. Ripple is less than 1 mv rms. Recovery time is less than 50 μsec. Temperature coefficient is less than 0.01 percent per degree centigrade. (Kepco Laboratories, Inc., Dept. 341)

■ STRIP-CHART RECORDER uses a 1 ma d-c d'Ars-o-nval movement to record on pressure-sensitive paper. The scale is rectilinear and 2 5/16 in. long. Chart length is 63 ft. To record, the meter pointer is pressed against the paper at 2-sec intervals. Chart speed is 8 in./hr and may be varied to 30 in./hr by means of gear-train inserts. Accuracy is ±2 percent of full scale. Size is 3⅝ by 5⅝ by 4⅛ in., weight 3½ lb. (Rust Industrial Co., Dept. 342)

■ RADIOGRAPHIC UNIT uses cobalt-60 to furnish radiation for inspection of heavy castings, weldments, and so forth. Six inches of steel can be radiographed in 15 min. The radiation source is contained in a steel-jacketed lead sphere flexibly mounted for aiming. A radiation shutter is controlled remotely. The equipment is mobile. (Picker X-Ray Corp., Dept. 346)

■ COMMUTATOR permits sampling of up to 100-voltage inputs at rates up to 1200 per sec. The commutator uses two groups of low-speed relays, two groups of high-speed relays, and two high-speed transistor switches. The relays are driven

by ring counters. The commutator is specifically designed to be used for input into the manufacturer's computer system. (Consolidated Electrodynamics, Dept. 345)

■ REMOTE-CONTROL HEAD for industrial television cameras is powered by two motors that provide tilt of 45 deg up or down and rotation of 370 deg. Cameras weighing up to 20 lb are handled. Operational speed is 2 deg/sec in elevation, and 3½ deg/sec in azimuth. (Houston Fearless Corp., Dept. 344)

■ VARIABLE-VOLTAGE SOURCE sweeps cyclicly through any voltage range up to 0 to 135 v at a rate of 10 v/sec. Output current capacity ranges from 2 to 20 amp for various models. The device consists of a motor-driven, reversible, variable autotransformer; a meter relay with independently adjustable upper- and lower-contact settings; and motor-control relays. (Amplifier Corporation of America, Dept. 347)

■ WAVEFORM ANALYZER is a superheterodyne instrument measuring the components of a complex waveform to a value −75 db below the fundamental over a frequency range of 50 to 20,000 cy/sec. Input level of the fundamental can be ±20 db relative to 1.0 mw into 600 ohm Frequency stability is ±1 percent, and response is flat within ±1 db. Input impedance is 100 kohm. (Wayne Kerr Instruments, Dept. 348)

■ DIGITAL VOLTMETER has accuracy of ±0.1 percent of full scale on any of six ranges from 0.01 to 1 v. Full-scale ranges or volts-per-digit values are continuously variable within each range step. Three decimal digits and the sign are displayed. Maximum read-out time, exclusive of reset and recording, is 0.8 sec. Output for operation of digital recording devices is available. (Data Instruments, Dept. 349)

■ LOAD INDICATOR uses a null-balance servo system to give continuous digital indication to 1 part in 1000. Accuracy is ±0.15 percent. The instrument accepts standard four-arm strain-gage transducers of 120 or 350 ohm. Full-scale response time is 5 sec. An integrating network can be switched in to smooth fluctuating signals. (Performance Measurements Co., Dept. 350)

■ OSCILLOSCOPE for panel mounting consists of a cathode-ray tube with 1¼- by 3-in. screen; high-voltage power supply; escutcheon with positioning, beam, and focus controls and an edge-lighted graph screen. Sensitivity is 56 v/in. vertical and 80 v/in. horizontal. Weight is less than 5 lb. (Waterman Products Inc., Dept. 353)

■ POWER-SUPPLY TESTER measures internal impedance of power sources of 0- to 500-v (d-c) output. Nine ranges cover full-scale impedance from 0.1 to 1000 ohm. Also provided are 12 voltage-indication ranges from 0.001 to 300 v full-scale. Accuracy is ±2 percent for resistance and ±5 percent for voltage at frequencies from 6 cy to 500 kcy/sec. (Alto Scientific Co., Inc., Dept. 355)

■ GAMMA INTENSITY RECORDER, a portable, battery-operated, transistorized ion chamber, operates unattended to record intensity of gamma radiation as a function of time. Recording is done on magnetic tape with tape reloading at 12- or 60-hr intervals. Accuracy is ±15 percent over the photon energy range of 0.2 to 2 Mev. Dose-rate levels from 0.1 to 100,000 r/hr may be recorded. (Land Air Inc., Dept. 351)

■ TENSILE TESTER is a pendulum-type table-model instrument. Speeds are variable between 2 and 20 in./min. Available ranges are 0 to 10, 0 to 30, and 0 to 100 lb. Other ranges can be supplied. A direct-reading elongation indicator is optional. (Thwing-Albert Instrument Co., Dept. 370)

■ METERING PUMP transfers liquids or gases through plastic or rubber tubing by means of rollers that compress the tubing. Tubing up to ¼ in. in diameter is accommodated. Models with flow rates as low as 2 ml/day and as high as 75 ml/min are available. The flow rate depends on the size of tubing, rotor speed, tubing compressibility, and roller pressure. Tubing can be inserted without access to the ends. (New Brunswick Scientific Co., Dept. 374)

■ TWO-PHASE POWER SUPPLY for 400-cy/sec operation provides three continuously variable outputs, two at 0 deg, and one at ±90 deg. Total output power is 580 volt-amp. All outputs are individually fused and are isolated from input. The ±90-deg output is isolated from the other two and can be switched rapidly to lead or lag. (Pacific Technical Co., Dept. 373)

■ MASS SPECTROMETER, for potassium-argon dating studies of minerals and rocks, consists of a glass spectrometer tube with an ion source and ion detector, analyzing magnet vacuum system, and associated electronic equipment. Evacuation is accomplished by a two-stage mercury diffusion pump and by pumping with the Bayard-Alpert gage provided for pressure measurement. Operating pressure of 10^{-11} mm-Hg is attained in 48 hr. (Atomic Laboratories Inc., Dept. 352)

JOSHUA STERN
National Bureau of Standards

PERSONNEL PLACEMENT

CLASSIFIED: 25¢ per word, minimum charge $4.25. Use of Box Number counts as 10 additional words. Payment in advance is required.

COPY for classified ads must reach SCIENCE 2 weeks before date of issue (Friday of every week).

DISPLAY: Rates listed below—no charge for Box number. Monthly invoices will be sent on a charge account basis — provided that satisfactory credit is established.

Single insertion	$26.00 per inch
13 times in 1 year	24.00 per inch
26 times in 1 year	23.00 per inch
52 times in 1 year	22.00 per inch

For PROOFS on display ads, copy must reach SCIENCE 4 weeks before date of issue (Friday of every week).

Replies to blind ads should be addressed as follows:
Box (give number)
Science
1515 Massachusetts Ave., NW
Washington 5, D.C.

POSITIONS WANTED

Biochemist, 1.5 years' postdoctoral experience. Metabolism lipides and nucleic acids. Modern methods, including isotopes, both fields. Particular interest—antitumor drugs. Box 211, SCIENCE. X

Immunochemist, 10 years' experience teaching and research, publications. Interested in university or research position. Box 209, SCIENCE. X

Pharmacologist; 8 years, professor and head, pharmacognosy department, state university; 4 years, director, research, pharmaceutical company. Medical Bureau, Burneice Larson, Director, 900 North Michigan, Chicago. X

POSITIONS OPEN

(a) **Biochemist** interested in full-time research involving electrophoresis and chromatography; plans for organizing radioisotope laboratory; Florida. (b) **Pharmacologist** to head department, pharmaceutical company; East. (c) **Biologist** qualified to direct research group engaged in study of schizophrenic and action of psychoactive drugs; university sponsored project; preferably scientist in assistant professor class or higher; Midwest. (d) **Scientist** qualified to serve as Spanish translator; preferably man with potential ability for key position; one of leading pharmaceutical companies. (e) **Young Biochemist**, Ph.D.; group association; $8400–$12,000; California. S9-3 Medical Bureau, Burneice Larson, Director, 900 North Michigan Avenue, Chicago. X

Biologist. Completed graduate work leading to Ph.D.; $5880–$7344; to study ecology and pollution of estuaries of Virginia. Virginia Fisheries Laboratory, Gloucester Point, Virginia. 9/19, 26; 10/3, 10, 17, 24, 31

NEW WORLD-WIDE GRADUATE AWARD DIRECTORIES for American Scientists, teachers, librarians to subsidize their education and research. Stipends $200–$10,000. Volume I (1957), $3; volume II (no duplication), special prepublication offer until 1 November, $2; both volumes $4 until 1 November. Limited edition. Complete, specific information on 400 awards in United States and overseas in each volume. CRUSADE, Sci., Box 99, Station G, Brooklyn 22, N.Y. ew

PHARMACOLOGIST
Ph.D. or Equivalent

Experience in practical pharmacology, with emphasis on gastrointestinal work qualifies you for an important position in the Warner-Lambert Research Institute.

Send complete résumé to:
Supervisor of Technical Employment
WARNER-LAMBERT RESEARCH INSTITUTE
Morris Plains, New Jersey

Ph.D. Pharmacologist interested in pharmacodynamics and drug evaluation. Real opportunity in growing pharmacology section of a progressive midwestern pharmaceutical company. No industrial experience required. Send salary requirements and résumé to Box 210, SCIENCE. 9/26; 10/3, 10

POSITIONS OPEN

(a) **Bacteriologist**; M.S., Ph.D., to head department, very large general hospital; responsible only to pathologist; $7000; mideastern industrial center. (b) **Chemist**; B.S., M.S., cognizant latest procedures; county health laboratory; minimum $6500; northeastern resort area. (c) **Research Biochemist**; Ph.D. trained chromatography, steroid chemistry for cancer research; teaching hospital; $7000; East. (d) **Chemist**; B.S., M.S., experienced micromethods for clinical and research work in pediatric microbiochemistry laboratory, university hospital; western mountain state. (e) **Bacteriologist**; experienced clinical bacteriology to head department, fully approved hospital now expanding from 400 beds; to $6000; Midwest. Woodward Medical Bureau, Ann Woodward, Director, 185 North Wabash, Chicago. X

POSITIONS OPEN

SCIENCE TEACHERS, LIBRARIANS, ADMINISTRATORS urgently needed for positions in many states and foreign lands. Monthly non-fee placement journal since 1952 gives complete job data, salaries. Members' qualifications and vacancies listed free. 1 issue, $1.00. Yearly (12 issues) membership, $5.00. CRUSADE, SCI., Box 99, Station G, Brooklyn 22 N.Y. ew

Virologist, State Virus Laboratory. Master's degree with virus training and 2 years' experience. Salary $440 to $550. Entrance step dependent on qualifications. Excellent opportunity in diagnostic and research activities in newly established and well-equipped laboratory. State Board of Health, Helena, Montana. 9/10, 26; 10/3

USE THIS EASY SELF-MAILER to obtain further information

19 September 1958

Readers' Service

Information Requisition

It's simple: Mark—Clip—Fold—Mail—No stamp required

This coupon is for your convenience—to facilitate your requests for further information about advertised products and items in Equipment.

From:

Name .... **Position** ....

Company ....

Street ....

City .... **Zone** .... **State** ....
(Please print or type)

Mark, clip coupon—FOLD HERE along this line—mail

Postage Will be Paid by Addressee

No Postage Stamp Necessary If Mailed in the United States

BUSINESS REPLY CARD
First Class Permit #12711 New York, N.Y.

Readers' Service

To: SCIENCE MAGAZINE
Room 740
11 West 42 Street
New York 36, New York

Fasten Here Only
Staple, Tape, Glue

POSITIONS OPEN

The Market Place

BOOKS • SERVICES • SUPPLIES • EQUIPMENT

DISPLAY: Rates listed below—no charge for Box number. Monthly invoices will be sent on a charge account basis — provided that satisfactory credit is established.

Single insertion	$26.00 per inch
13 times in 1 year	24.00 per inch
26 times in 1 year	23.00 per inch
52 times in 1 year	22.00 per inch

For **PROOFS** on display ads, copy must reach SCIENCE 4 weeks before date of issue (Friday of every week).

19 September 1958

Readers' Service

Information Requisition

Use this easy self-mailer to obtain further information about items or literature from the Equipment section as well as from advertised products.

EQUIPMENT

Circle below desired number corresponding to:

330	332	341	342	344	345	346	347	348
349	350	351	352	353	355	370	373	374

ADVERTISERS IN THIS ISSUE

In list below, check page number of advertiser from whom you would like more information. If more than one item appears in ad, letters (A, B, C) are used to indicate particular items available in order of appearance in advertisement. Where more than one ad appears on page, **"U" indicates upper ad, "L" lower ad, "I" inside ad, "M" middle ad,** and **"O" outside ad.** Advertisements in Personnel Placement and Market Place are not keyed. A multiplicity of items is indicated by *. Readers are requested to specify on this coupon the particular item in which they are interested; otherwise, the request cannot be processed.

☐ 622	☐ 623	☐ 624	☐ 625	☐ 626*
☐ 627	☐ 628	☐ 630	☐ 668, U	☐ 668, LO
☐ 668, LM	☐ 669	☐ 670, A	☐ 670, B	☐ 671, UI
☐ 671, UO	☐ 671, L	☐ 672	☐ 673	☐ 674
☐ 675, UI	☐ 675, UO	☐ 675, L	☐ 676	☐ 677, UI
☐ 677, UO	☐ 677, LO	☐ 678, O	☐ 678, UI	☐ 679
☐ 680, A	☐ 680, B	☐ 684		

BOOKS AND MAGAZINES

PROFESSIONAL SERVICES

SUPPLIES AND EQUIPMENT

APPLICATION FOR HOTEL RESERVATIONS

125th AAAS MEETING

Washington, D.C., December 26-31, 1958

The list of hotels and their rates and the reservation coupon below are for your convenience in making your hotel room reservation in Washington. Please send your application, *not* to any hotel directly, but to the AAAS Housing Bureau in Washington and thereby avoid delay and confusion. The experienced Housing Bureau will make assignments promptly; a confirmation will be sent you in two weeks or less.

As in any city, single-bedded rooms at minimum rates may become scarce; double rooms for single occupancy cost more; for a lower rate, share a twin-bedded room with a colleague. Most hotels will place comfortable rollaway beds in rooms or suites at $2.00 to $2.50 per night. Mail your application *now* to secure your first choice of desired accommodations. All requests for reservations must give a definite date and estimated hour of arrival, and also probable date of departure.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

Rates for Rooms with Bath

Hotels with an asterisk have sessions in their public rooms. For a list of headquarters of each participating society and section, see page 151, *Science,* July 18.

Hotel	Single	Double Bed	Twin Bed	Suite
*Dupont Plaza	$10.00–11.00	$13.00–14.00	$13.00–14.00	$21.00–27.00
*Sheraton-Park	8.00–12.00	12.00–14.50	11.00–16.00	20.00–60.00
*Shoreham	all 9.00	all 12.00	all 12.00	20.00–50.00
*Statler	all 10.00	all 14.00	all 14.00	24.00–30.00
*Washington	7.00– 8.00	11.00–12.50	11.00–12.50	24.50–45.00
*Willard	10.00–12.50	13.00–17.00	14.00–18.00	25.00–35.00
Roosevelt	7.00– 9.00		10.00–12.00	18.00–24.00
Sheraton-Carlton	12.00–17.00		17.00–21.00	
Windsor Park	all 9.00	all 14.00	all 14.00	13.00–18.00

-------------- **THIS IS YOUR HOUSING RESERVATION COUPON** --------------

AAAS Housing Bureau
1616 K Street, N.W.
Washington 6, D.C.

Date of Application ....

Please reserve the following accommodations for the 125th Meeting of the AAAS in Washington, D.C., Dec. 26–31, 1958:

TYPE OF ACCOMMODATION DESIRED

Single Room .... Desired Rate .... Maximum Rate ....

Double-Bedded Room .... Desired Rate .... Maximum Rate .... Number in party ....

Twin-Bedded Room .... Desired Rate .... Maximum Rate ....

Suite .... Desired Rate .... Maximum Rate .... Sharing this room will be:

(Attach list if this space is insufficient. The name and address of each person, including yourself, must be listed.)

....

....

First Choice Hotel .... Second Choice Hotel .... Third Choice Hotel ....

DATE OF ARRIVAL .... DEPARTURE DATE ....

(These must be indicated—add approximate hour, a.m. or p.m.)

NAME ....

(Individual requesting reservation) (Please print or type)

ADDRESS ....

(Street) (City and Zone) (State)

***Mail this now to the Housing Bureau.* Rooms will be assigned and confirmed in order of receipt of reservation.**